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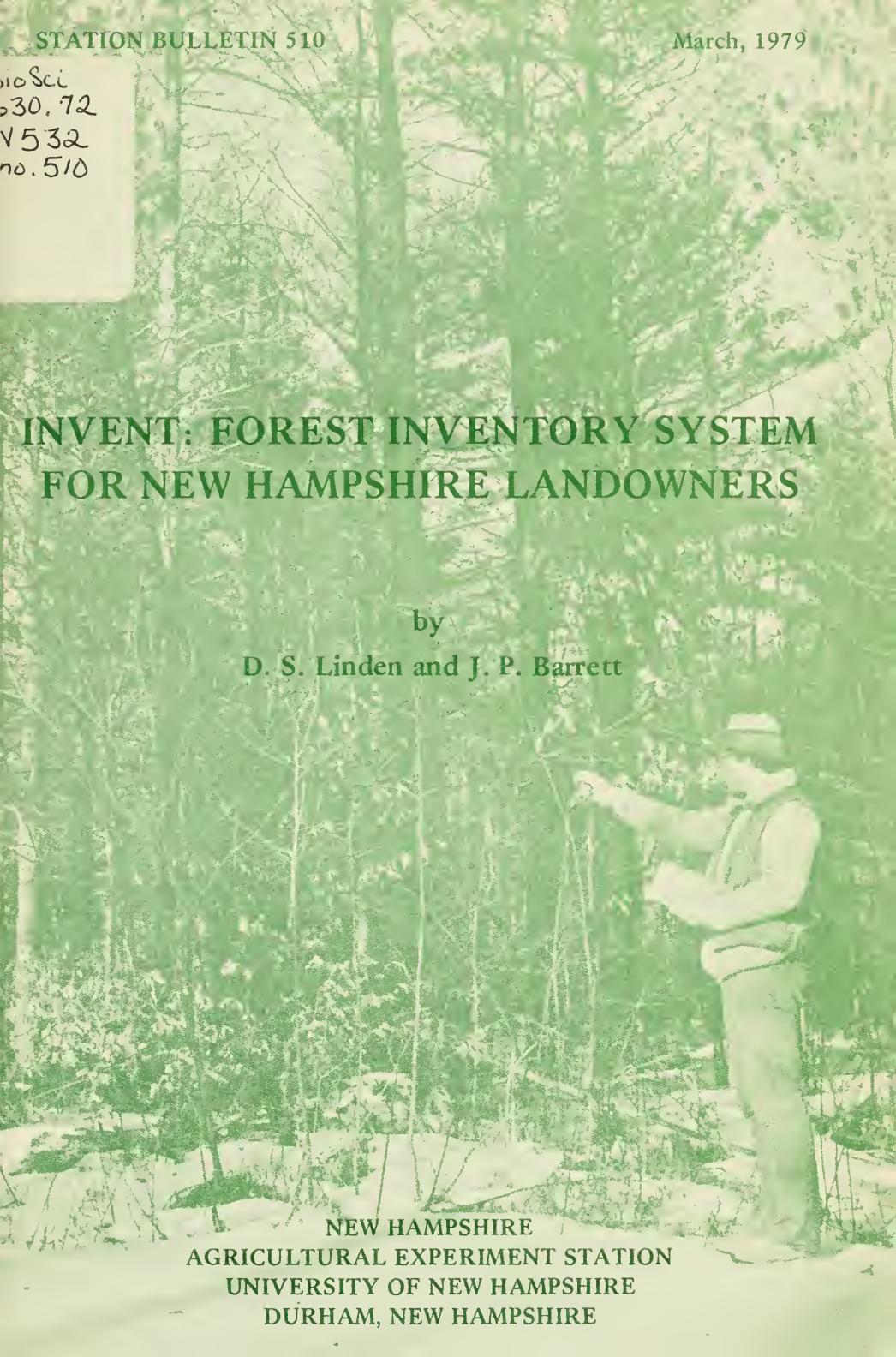
INVENT: FOREST INVENTORY SYSTEM FOR NEW HAMPSHIRE LANDOWNERS

by
D. S. Linden and J. P. Barrett



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The program was written in FORTRAN-10 on the DECsystem-10 Model 1090 Computer at the University of New Hampshire. A card deck of the program may be obtained by contacting:

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ABSTRACT

A computerized forest inventory system has been developed to meet the needs of New Hampshire landowners and foresters. The system will analyse all sampling designs currently in wide use throughout the State producing tables easily understood by landowners. The system includes a rigorous statistical analysis of volume standard errors as well as a newly developed height double sampling technique. The system is available through the Institute of Natural and Environmental Resources.

KEY WORDS: Forest inventory. Computer inventory. Sampling. Double sampling.

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INVENT:

FOREST INVENTORY SYSTEM FOR NEW HAMPSHIRE LANDOWNERS

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INTRODUCTION

INVENT is a computerized forest inventory processing system designed for New Hampshire landowners. INVENT was designed with the following five goals in mind:

1. Produce a system that will analyse all sampling designs and methods presently in wide use throughout the State.
2. Produce output tables easily understood by foresters and landowners--output tables that look as if they were designed by a forester, not a computer.
3. Find and implement volume equations that are well adapted to the New Hampshire species--calculate both board-foot and cubic-foot volumes.
4. Indicate the reliability of volume estimates.
5. Produce a system that any forester can use and understand--a system available to all foresters at low cost.

The realization of these goals is the result of two years work in close cooperation with consulting foresters, county foresters, and forest industry. As a result, New Hampshire foresters have "been emancipated from the drudgery and limitations of computation and can concentrate on forest data needs." (Davis 1966, p. 282).

The use of INVENT is made available by the Institute of Natural and Environmental Resources at the University of New Hampshire. Institute personnel will process data from tally sheets submitted by subscribing foresters. Persons interested in using the system should contact Professor James Barrett at I.N.E.R., University of New Hampshire.

This publication is written in four separate sections. Section 1 contains all the information a field forester needs to know to utilize the service. Section 2 describes how the data is computer coded and how the program is run. Section 3 documents the computer program itself with subroutine descriptions

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and variable dictionaries. Section 4 discusses the statistical techniques used within the program. The appendices include tally forms, species code list, volume equations, a guide to sample size determination, a program listing and other supportive material.

SECTION 1. FIELD FORESTER INFORMATION

The first step in a forest inventory is to systematically arrange the forest into groups or categories based upon some definite scheme. We shall refer to these groups as either compartments or strata, using these terms interchangeably. The boundaries of these compartments may be determined by forest type, stocking level, merchantability class or administrative convenience. Whatever the criteria actually used, INVENT will assume that each compartment should be processed individually and will produce a complete set of summary tables for each compartment. Furthermore, INVENT will produce a set of summary tables for all compartments combined assuming stratified random sampling (Cf. Freese 1962). INVENT will handle up to 999 compartments although in practice one would seldom have more than 20 compartments within any forest.

For each forest to be processed, the forester must supply the information requested on the INVENT Processing Request Form (Appendix A, page 48). This information includes:

1. Name and address of forester making request.
2. Number of compartments in the forest.
3. Alternate form class specification.
4. Diameter class size.
5. Confidence level.
6. Tract description.

Alternate Form Class Specification. If heights are measured to the merchantable top, form class equations are used to determine board foot volume. INVENT uses the following form classes as a default:

Hemlock 70 All other softwoods 76 All hardwoods 74

Alternate form classes may be specified using the space provided on the INVENT Processing Request Form. These form classes will be used for all compartments in the forest.

Diameter Class Size. INVENT assumes that trees will be grouped into diameter classes. The size of the class is up to the user within the following limitations. The class size must be a whole number. The smallest diameter class allowable is the class size; i.e., if the class size is 2 in. then the first class must be 2 inches. All other diameter classes must be integer multiples of the class size. The maximum diameter class must be less than or equal to 40 inches.

Confidence Level. INVENT uses the 95 percent confidence level as a default. Using this level, there is only a one in twenty chance that the true volume will be outside the confidence interval computed by INVENT (Cf. Freese 1967, p. 11). This is the most common confidence level used in forestry in the Northeast. If the user wishes to use a different level, he may specify that level as long as it is in the range from 65 percent to 99 percent.

Tract Description. A tract description of up to 70 characters should be specified for the forest. This description will be printed at the top of each page of the combined compartment summaries.

For each compartment within the forest, the forester must supply the information requested on the INVENT Compartment Information Form (Appendix A, page 49). This information includes:

1. Compartment name and/or description.
2. Sampling method and sample unit size.
3. Tree height measurement units.
4. Tree top specification.
5. Whether or not the heights of all volume trees were measured.
6. Size of compartment in acres.

Compartment Name. A compartment name and/or description should be specified for each compartment. The description may be up to 70 characters in length and is printed at the top of each page of the compartment output tables.

Sampling Method. INVENT will process point cruises (variable plot), plot cruises (fixed radius plot), strip cruises, and 100 percent tallies. The sampling method need not be the same for each compartment. When using point or plot sampling, a complete statistical analysis of the reliability of the volume estimates will be calculated only if the data for each point or plot is tallied separately. If only summary data is available, no such statistical analysis can be made. When point sampling, the BAF of the angle used must be specified. When plot sampling, the plot size in acres must be specified. Strip cruises are analysed as a plot cruise where only one large plot is sampled. In this case, the plot size is the total acreage of all strips. There is no statistical analysis of reliability on strip cruises. One hundred percent tallies require no statistical analysis of reliability since all trees in the population have been measured. One hundred percent tallies are also treated as a plot cruise where only one large plot is sampled. Here, however, the plot size is equal to the total acreage of the compartment.

Tree Height Measurement. Tree height may be measured in feet or sixteen foot logs to the nearest half-log.

Tree Top Specification. Trees may be measured to a merchantable top or measured by total height. There is also a mixed option where softwoods are measured by total height and hardwoods by merchantable height. As mentioned earlier, form class volume equations for board foot volume are used when merchantable height is specified.

Were Heights of All Volume Trees Measured? INVENT allows double sampling for height (Cf. Freese 1962, p. 43). Using this technique, the forester only measures height on a subsample of the trees. INVENT develops a height-dbh relationship from the height trees sampled and uses this relationship to estimate height for the remaining trees. This method must be used with some caution. On at least one-third of the trees in every species, the height should be measured. At least three height trees must be measured for every species within each compartment. An analysis table of the height-dbh relationship is printed for each compartment using the option. A warning message is

printed if an insufficient number of trees within any species was sampled. (See table 17).

Size of Compartment. The size of each compartment in acres must be specified. If not known exactly it must at least be estimated.

Tally Forms and Product Specification

Tally forms are available for use with INVENT (see Appendix A, page 46). Trees are tallied using a two letter species code (Appendix A, page 45), diameter class, height and product. The product column is used as follows: INVENT allows trees to be graded as sawlog or pulpwood. If you do not wish to grade trees simply ignore the product column and all trees will be assumed sawlog. If you do wish to grade trees there are two methods available. You can grade the entire tree as sawlog or pulpwood by entering an S in the product column for sawlog, or entering a P for pulpwood. Alternatively, you may specify the percent sawlog in the tree. If you put 60 in the product column, 60 percent of the volume will go into sawlog and 40 percent will go into pulpwood.

The column marked # is used if two or more trees of the same species, size and product are tallied on a given plot.

Output Tables

Seventeen tables are presented as an example of INVENT's output. Tables 1-16 are part of a 59 page inventory report based on a 3 compartment cruise of Whitaker Woods in North Conway, N.H. Tables 1-9 are for compartment 1 while tables 10-16 are for all 3 compartments combined. Table 17 is taken from another cruise where the height double sampling option was used. This table is a summary of that relationship. The output tables are further discussed in section 3 on page 34. However, the tables should be self-explanatory to most foresters.

TABLE 1. JOB CONTROL INFORMATION (INDIVIDUAL STRATUM)

INVENT VER. 3 11/1/78 I.N.E.R. U.M.H.

DATE OF RUN: 7-Dec-78

B.A.F. = 10.00
DIAMETER CLASS SIZE = 2
HEIGHTS OF ALL VOLUME TREES MEASURED
INPUT FILE NAME: CONWIT.C1
CONFIDENCE LEVEL = .95

NUMBER OF POINTS SAMPLED = 20
HEIGHTS MEASURED BY MERCH HEIGHT IN LOGS
STRATUM # 1
ACREAGE OF TRACT = 47.0

TABLE 2. SPECIES STAND AND STOCK TABLE

WHITE PINE FC = 76

DIAMETER CLASS	BASAL AREA PER ACRE	TREES PER ACRE	SAWLOG CUBIC FOOT VOLUME PER ACRE	SAWLOG BOARD FOOT VOLUME PER ACRE	PDLPWOOD CUBIC FOOT VOLUME PER ACRE
8	1.5	4.3	0.0	0.0	30.7
10	1.0	1.8	16.8	82.8	0.0
12	4.5	5.7	91.1	535.4	0.0
14	5.0	4.7	109.9	705.8	0.0
16	7.5	5.4	168.7	1115.0	16.4
18	9.0	5.1	221.1	1545.0	9.6
20	7.0	3.2	196.5	1405.3	0.0
22	3.5	1.3	101.6	747.0	0.0
24	2.5	0.8	70.3	538.0	0.0
26	4.5	1.2	134.1	1035.6	0.0
28	1.0	0.2	33.7	258.3	0.0
30	1.0	0.2	28.4	233.1	0.0
32	2.0	0.4	58.4	483.9	0.0
TOTAL	50.0	34.3	1230.6 ± 35%	8685.2 ± 35%	56.7 ± 83%

MEAN STAND DIAMETER = 16.3
MERCHANTABLE M.S.D. = 16.3
PERCENT CRUISE = 6.2%

BOARD FOOT COEFFICIENT OF VARIATION = 78%
PULP-WOOD COEFFICIENT OF VARIATION = 183%

TABLE 3. SPECIES STAND AND STOCK TABLE

RED OAK FC = 74

DIAMETER CLASS	BASAL AREA PER ACRE	TREES PER ACRE	SAWLOG CUBIC FOOT VOLUME PER ACRE	SAWLOG BOARD FOOT VOLUME PER ACRE	PULPWOOD CUBIC FOOT VOLUME PER ACRE
6	1.0	5.1	0.0	0.0	19.4
8	1.5	4.3	6.1	26.3	16.7
10	4.5	8.3	54.1	273.4	13.2
12	5.5	7.0	72.4	417.1	0.0
14	2.0	1.9	30.9	183.9	0.0
16	2.0	1.4	28.2	179.2	0.0
18	3.0	1.7	41.8	277.1	0.0
20	1.5	0.7	25.1	165.4	0.0
22	0.5	0.2	4.6	35.6	0.0
TOTAL	21.5	30.5	263.3 ± 58%	1557.9 ± 56%	49.3 ±151%

MEAN STAND DIAMETER = 11.4 BOARD FOOT COEFFICIENT OF VARIATION = 122%

MERCHANTABLE M.S.D. = 12.2 PULP-WOOD COEFFICIENT OF VARIATION = 327%

PERCENT CRUISE = 3.0%

TABLE 4. SOFTWOOD SUMMARY STAND AND STOCK TABLE

ALL SOFTWOODS

DIAMETER CLASS	BASAL AREA PER ACRE	TREES PER ACRE	SAWLOG CUBIC FOOT VOLUME PER ACRE	SAWLOG BOARD FOOT VOLUME PER ACRE	PULPWOOD CUBIC FOOT VOLUME PER ACRE
6	0.5	2.5	0.0	0.0	8.1
8	3.5	10.0	0.0	0.0	57.3
10	7.0	12.8	86.1	392.6	4.0
12	10.5	13.4	169.7	956.7	0.0
14	9.0	8.4	183.7	1147.4	0.0
16	11.5	8.2	238.4	1574.8	16.4
18	13.5	7.6	307.3	2079.7	9.6
20	8.5	3.9	226.6	1593.2	0.0
22	4.5	1.7	125.5	915.2	0.0
24	2.5	0.8	70.3	538.0	0.0
26	4.5	1.2	134.1	1035.6	0.0
28	1.0	0.2	33.7	258.3	0.0
30	1.0	0.2	28.4	233.1	0.0
32	2.0	0.4	58.4	483.9	0.0
TOTAL	79.5	71.5	1662.2 ± 29%	11208.3 ± 30%	95.4 ± 63%

MEAN STAND DIAMETER = 14.3 BOARD FOOT COEFFICIENT OF VARIATION = 65%

MERCHANTABLE M.S.D. = 14.5 PULP-WOOD COEFFICIENT OF VARIATION = 138%

PERCENT CRUISE = 4.7%

TABLE 5. HARDWOOD SUMMARY STAND AND STOCK TABLE

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ALL HARDWOODS

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DIAMETER CLASS	BASAL AREA PER ACRE	TREES PER ACRE	SAWLOG CUBIC FOOT VOLUME PER ACRE	SAWLOG BOARD FOOT VOLUME PER ACRE	PULPWOOD CUBIC FOOT VOLUME PER ACRE
6	3.0	15.3	0.0	0.0	48.6
8	3.5	10.0	6.1	26.3	47.8
10	6.0	11.0	60.0	302.8	25.2
12	7.5	9.5	77.3	448.5	14.4
14	3.0	2.8	43.8	260.4	0.0
16	2.5	1.8	35.8	224.4	0.0
18	3.0	1.7	41.8	277.1	0.0
20	1.5	0.7	25.1	165.4	0.0
22	0.5	0.2	4.6	35.6	0.0
TOTAL	30.5	53.0	294.7 ± 52%	1740.5 ± 51%	136.0 ± 72%

MEAN STAND DIAMETER = 10.3

MERCHANTABLE M.S.D. = 11.6

PERCENT CRUISE = 2.4%

BOARD FOOT COEFFICIENT OF VARIATION = 109%

PULP-WOOD COEFFICIENT OF VARIATION = 157%

TABLE 6. ALL SPECIES SUMMARY STAND AND STOCK TABLE

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ALL SPECIES

****

DIAMETER CLASS	BASAL AREA PER ACRE	TREES PER ACRE	SAWLOG CUBIC FOOT VOLUME PER ACRE	SAWLOG BOARD FOOT VOLUME PER ACRE	PULPWOOD CUBIC FOOT VOLUME PER ACRE
6	3.5	17.8	0.0	0.0	56.7
8	7.0	20.1	6.1	26.3	105.1
10	13.0	23.8	146.1	695.4	29.2
12	18.0	22.9	246.9	1405.2	14.4
14	12.0	11.2	227.6	1407.8	0.0
16	14.0	10.0	274.3	1799.2	16.4
18	16.5	9.3	349.1	2356.7	9.6
20	10.0	4.6	251.7	1758.6	0.0
22	5.0	1.9	130.1	950.8	0.0
24	2.5	0.8	70.3	538.0	0.0
26	4.5	1.2	134.1	1035.6	0.0
28	1.0	0.2	33.7	258.3	0.0
30	1.0	0.2	28.4	233.1	0.0
32	2.0	0.4	58.4	483.9	0.0
TOTAL	110.0	124.5	1956.8 ± 21%	12948.9 ± 22%	231.4 ± 50%

MEAN STAND DIAMETER = 12.7

MERCHANTABLE M.S.D. = 13.5

PERCENT CRUISE = 3.8%

BOARD FOOT COEFFICIENT OF VARIATION = 48%

PULP-WOOD COEFFICIENT OF VARIATION = 109%

TABLE 7. SPECIES COMPOSITION TABLE

SPECIES COMPOSITION BY PERCENT

SPECIES	BASAL AREA	TREES	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
WHITE PINE	45.45	27.59	62.89	67.07	24.50
RED PINE	5.91	5.15	6.90	6.76	0.00
HEMLOCK	20.91	24.67	15.15	12.72	16.75
SUGAR MAPLE	0.91	3.20	0.00	0.00	6.82
RED MAPLE	0.91	1.53	0.26	0.25	3.68
WHITE BIRCH	0.91	2.56	0.25	0.24	3.92
BEECH	5.45	10.80	1.09	0.91	23.03
RED OAK	19.55	24.51	13.46	12.03	21.31
ALL SOFTWOODS	72.27	57.41	84.94	86.56	41.25
ALL HARDWOODS	27.73	42.59	15.06	13.44	58.75

TABLE 8. VOLUME SUMMARY FOR ALL SPECIES

VOLUME TOTALS FOR ALL SPECIES

SPECIES	SAWLOG CUBIC FOOT VOLUME PER ACRE	SAWLOG BOARD FOOT VOLUME PER ACRE	PULPWOOD CUBIC FOOT VOLUME PER ACRE
WHITE PINE	1230.6	8685.2	56.7
RED PINE	135.0	876.0	0.0
HEMLOCK	296.5	1647.2	38.8
SUGAR MAPLE	0.0	0.0	15.8
RED MAPLE	5.1	32.8	8.5
WHITE BIRCH	4.8	31.4	9.1
BEECH	21.4	118.4	53.3
RED OAK	263.3	1557.9	49.3
ALL SOFTWOODS	1662.2	11208.3	95.4
ALL HARDWOODS	294.7	1740.5	136.0
ALL SPECIES	1956.8	12948.9	231.4

TABLE 9. VOLUME SUMMARY FOR ALL SPECIES EXPANDED BY ACREAGE

VOLUME TOTALS EXPANDED BY ACREAGE

SPECIES	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
WHITE PINE	57838	408202	2664
RED PINE	6347	41170	0
HEMLOCK	13936	77419	1822
SUGAR MAPLE	0	0	742
RED MAPLE	240	1542	400
WHITE BIRCH	228	1478	426
BEECH	1004	5563	2505
RED OAK	12377	73222	2317
ALL SOFTWOODS	78122	526792	4486
ALL HARDWOODS	13849	81805	6390
ALL SPECIES	91971	608597	10876

TABLE 10. JOB CONTROL INFORMATION (STRATIFIED TOTAL)

INVENT VER. 3 11/1/78 I.N.E.R. U.N.H.

DATE OF RUN: 7-Dec-78

DIAMETER CLASS SIZE = 2 NUMBER OF STRATA SAMPLED = 3

TOTAL ACREAGE SAMPLED = 105.0 TOTAL POINTS SAMPLED = 56

CONFIDENCE LEVEL = .95

TABLE 11. SPECIES VOLUME TABLE (STRATIFIED TOTAL)

WHITE PINE — FC = 76

DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	0	0	914
8	823	2718	1716
10	1499	7465	0
12	5111	30058	0
14	5550	35604	0
16	9600	63484	769
18	14541	100826	453
20	14468	103635	0
22	10177	75100	0
24	7902	60263	0
26	9247	71309	0
28	2506	19544	0
30	2074	16148	0
32	4228	34874	0
34	568	4555	0
36	455	3920	0
TOTAL	88750 ± 26%	629503 ± 26%	3853 ± 73%

TABLE 12. SPECIES VOLUME TABLE (STRATIFIED TOTAL)

RED OAK — FC = 74

DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	0	0	1635
8	288	1234	2981
10	4574	23270	622
12	7579	42632	310
14	2901	16995	0
16	4710	29345	0
18	3005	19598	664
20	1403	9308	294
22	218	1674	0
24	0	0	291
28	290	2035	0
TOTAL	24968 ± 37%	146091 ± 36%	6799 ± 61%

TABLE 13. SOFTWOOD SUMMARY VOLUME TABLE (STRATIFIED TOTAL)

ALL SOFTWOODS

DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	0	0	1874
8	1053	3451	4161
10	6105	28274	320
12	10944	61345	107
14	12957	79177	0
16	22644	141792	769
18	26139	172099	591
20	18292	127282	0
22	13103	95876	0
24	9151	68560	0
26	10723	81395	0
28	2799	21620	0
30	3291	24339	0
32	4407	36297	0
34	915	7039	0
36	455	3920	0
40	459	3204	0
TOTAL	143437 ± 19%	955670 ± 19%	7822 ± 50%

TABLE 14. HARDWOOD SUMMARY VOLUME TABLE (STRATIFIED TOTAL)

ALL HARDWOODS

DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	366	607	7887
8	288	1234	11231
10	9417	48605	2785
12	10012	56781	2805
14	4167	24463	826
16	5472	34023	488
18	3005	19598	1212
20	1403	9308	458
22	381	2825	610
24	0	0	607
26	315	2009	237
28	290	2035	0
TOTAL	35115 ± 26%	201490 ± 26%	29146 ± 27%

TABLE 15. ALL SPECIES SUMMARY VOLUME TABLE (STRATIFIED TOTAL)

ALL SPECIES

DIAMETER CLASS	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
6	366	607	9760
8	1341	4685	15393
10	15522	76879	3104
12	20955	118127	2912
14	17124	103641	826
16	28116	175815	1257
18	29144	191697	1803
20	19695	136589	458
22	13484	98701	610
24	9151	68560	607
26	11038	83404	237
28	3089	23655	0
30	3291	24339	0
32	4407	36297	0
34	915	7039	0
36	455	3920	0
40	459	3204	0
TOTAL	178552 ± 14%	1157160 ± 14%	36968 ± 22%

TABLE 16. VOLUME SUMMARY FOR ALL SPECIES (STRATIFIED TOTAL)

VOLUME TOTALS FOR ALL SPECIES

SPECIES	SAWLOG CUBIC FOOT VOLUME	SAWLOG BOARD FOOT VOLUME	PULPWOOD CUBIC FOOT VOLUME
WHITE PINE	88750	629503	3853
RED PINE	10094	65651	0
HEMLOCK	44593	260516	3746
RD-BL-WH SPRUCE	0	0	224
SUGAR MAPLE	0	0	742
RED MAPLE	1072	6271	6150
WHITE BIRCH	4474	25213	3255
YELLOW BIRCH	89	649	0
BEECH	4513	23266	12200
RED OAK	24968	146091	6799
ALL SOFTWOODS	143437	955670	7822
ALL HARDWOODS	35115	201490	29146
ALL SPECIES	178552	1157160	36968

TABLE 17. REGRESSION SUMMARY (IF OPTION USED)

ANALYSIS OF THE HEIGHT - DBH RELATIONSHIP

MODEL: HEIGHT = B0 + B1/DBH

SPECIES	B0 INTERCEPT	B1 SLOPE	R SQUARED	STANDARD ERROR %	AVERAGE HEIGHT	VOLUME TREES	HEIGHT TREES
WHITE PINE	3.296	-21.321	54.0	5.1	1.5	92	40
HEMLOCK	1.799	-8.528	16.2	9.6	1.1	48	23
RED MAPLE	3.106	-29.436	62.1	13.5	0.9	39	11
BLACK CHERRY		*** WARNING ***		0.0	0.0	3	0
SWEET BIRCH		*** WARNING ***		0.0	0.0	1	0
BASSWOOD				0.0	2.0	2	2
RED OAK	1.140	-5.471	30.1	19.7	0.8	5	4
WHITE OAK		*** WARNING ***		0.0	0.0	3	0
BLACK OAK		*** WARNING ***		0.0	0.0	2	0
ELM	1.157	-4.992	18.7	15.0	0.8	9	6
HICKORY	2.865	-23.076	73.0	9.2	1.3	6	3
ALL SOFTWOODS				4.6	1.4	140	63
ALL HARDWOODS				8.1	1.0	70	26
ALL SPECIES				4.1	1.3	210	89

*** WARNING *** INSUFFICIENT NUMBER OF HEIGHT TREES MEASURED FOR THIS SPECIES!

SECTION 2. DATA CODING AND PROGRAM EXECUTION

Program Operating Environment

INVENT was developed on the DEC-10 system at the University of New Hampshire. INVENT is an interactive system acquiring all of its job control related information from the user through a dialogue. Unit 5 (TTY on DEC-10) is used as the input and output device for all of INVENT's interactive dialogue.

For each stratum the plot and tree data must reside on a disk file with a unique name. The name of the file is specified by the user at execution time as INVENT processes each stratum. Unit 21 is used to input each disk file. The file uses a fixed format as described below.

If the user wishes to use alternate form classes, these must reside on a disk file also. The user specifies the name of this file at execution time and unit 1 is used to input this file. The file uses a fixed format as described on page 18.

All output is written to unit 3 (LPT on DEC-10) to a file named INVENT.LPT.

Data File Format and Coding

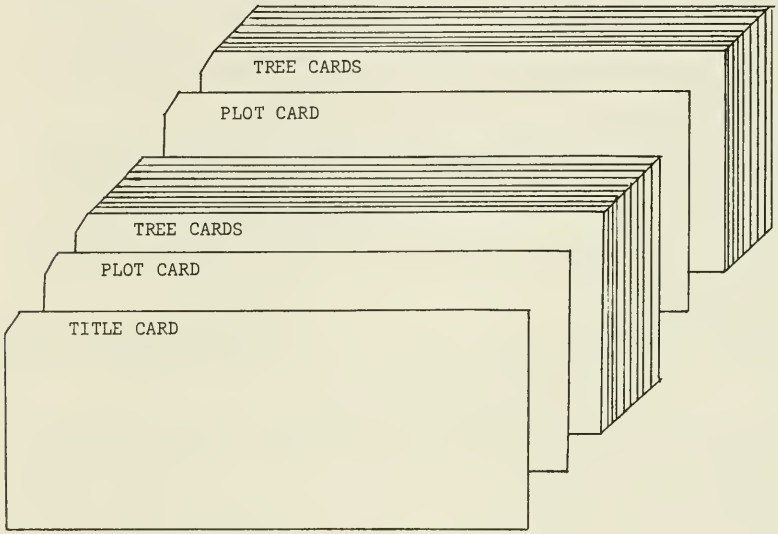
An individual data file must exist for each stratum. The file consists of card images coded as follows:

Card Type	Columns	Format	Variable	Description
Title	1-70	12A5	TITLE	Stratum title
Plot	1-2	I2	POINT	Plot number (1)
	3-5	I3	TREES	Number of trees on plot (1)
Tree	1-2	A2	SPEC	Species code
	4-5	I2	DBH	Diameter at breast height
	6	A1	PROD	Product code (2)
	7-9	F3.0	HEIGHT	Tree height
	10-11	I2	IREP	Number of trees of this description (3)
	12-14	F3.2	PCTSAW	Percent sawlog (4)

(1) When using the summary option where trees are not tallied by individual plots, only one plot card is used and it is coded as follows: POINT = -9, TREES = number of plots sampled.
(2) Product codes: Sawlog (S or blank); Pulpwood (P); Percent Sawlog (%).
(3) If IREP is coded as 0 or blank, the program assumes IREP = 1.
(4) PCTSAW is ignored unless PROD = %. PCTSAW is coded as a percent (0-100) and the F3.2 format reads it as a decimal (0-1.00).

Examples of various tree card codings may be found in Appendix A, page 44. The species code list is found in Appendix A, page 45.

The data file is constructed by combining the title, plot, and tree cards as follows. The first card in the file is the title card. This is followed by the plot card for plot number 1. The plot card is then followed by all the tree cards for that plot. Next, the plot card for plot number 2 is included followed by its tree cards; and so on for the remaining plots. The actual value of POINT (plot number) need not be consecutive.



An example of an INVENT tally sheet and the resulting data file listing may be found in Appendix A, pages 46 and 47.

Alternate Form Class File Coding

The user has the option to specify a set of alternate form classes. Form class only affects volume when tree heights are measured to a merchantable top (see page 3). A file containing these alternate form classes must reside on a disk file. This file consists of four rows and eight columns organized as follows:

Row 1:	Form classes for species	1-8 (see species list in
Row 2:	" " " "	9-16 Appendix A, page 45)
Row 3:	" " " "	17-24
Row 4:	" " " "	25-32

Each row is formatted 8(I2,X).

As an example, assume the following form classes were desired:

All pines	80
Hemlock, Spruces, Ash, Black Cherry	78
Balsam Fir, Tamarack, Cedar Other Softwoods, Sugar Maple White Birch, Yellow Birch	76
All other species	75

The data file that would implement these form classes is:

```
80 80 80 78 76 76 78 78
80 76 76 76 75 78 75 75
75 78 76 76 75 75 75 75
75 75 75 75 75 75 75 75
```

Running the Program

Running INVENT consists of interactively supplying the program all job control information. This information includes: alternate form class specification (if desired), diameter class size, number of strata, confidence level, input file name for each strata, sampling method (point or plot), basal area factor or plot size, method of height measurement, acreage of each stratum, and title of combined strata output (if more than one stratum sampled).

This interactive portion of the program is self-explanatory. The program asks the user certain questions while listing the possible answers. The number of questions asked depends on the options used and the number of strata sampled. The questions are asked as each data file is read and processed. Under conditions of heavy computer usage there may be a time lapse of as much as two minutes between certain questions. This process is best explained by example.

Tables 1-16 are part of a 59 page inventory report based on a 3 compartment cruise of Whitaker Woods in North Conway, N.H. Listed below is the entire user-program dialogue that produced that output. Each of the questions asked has been numbered for reference and user responses are underlined. Most questions are totally self-explanatory and therefore only a few will be discussed.

```
.RUN INVENT

1.  DO YOU WANT TO READ IN ALTERNATE FORM CLASSES FROM DISK?
    NO

2.  ENTER DIAMETER CLASS SIZE
    2

3.  ENTER NUMBER OF STRATA
    3

4.  INVENT USES THE 95% CONFIDENCE LEVEL AS A DEFAULT.
    DO YOU WISH TO USE A DIFFERENT LEVEL?
    NO

5.  ENTER INPUT FILE NAME FOR STRATUM #   1
    CONWIT.C1

    WHITAKER WOODS  1978   COMP. 1

6.  SPECIFY SAMPLING METHOD
      TYPE POINT OR PLOT
    POINT

7.  ENTER B.A.F.
    10

8.  ARE HEIGHTS IN FEET OR SIXTEEN FT. LOGS?
        TYPE FEET OR LOGS
    LOGS

9.  ARE HEIGHTS TOTAL OR MERCHANTABLE?
        TYPE TOTAL, MERCH, OR MIXED
    MERCH

10. WERE THE HEIGHTS OF ALL VOLUME TREES MEASURED?
    YES

11. ENTER ACREAGE OF TRACT.
    47

12. ENTER INPUT FILE NAME FOR STRATUM #   2
    CONWIT.C2

    WHITAKER WOODS  1978   COMP. 2
```

```
13.     SPECIFY SAMPLING METHOD
          TYPE POINT OR PLOT OR SAME
        SAME

14.     ENTER ACREAGE OF TRACT.
        42

15.     ENTER INPUT FILE NAME FOR STRATUM #   3
        CONWIT.C3

        WHITAKER WOODS  1978   COMP. 3

16.     SPECIFY SAMPLING METHOD
          TYPE POINT OR PLOT OR SAME
        SAME

17.     ENTER ACREAGE OF TRACT.
        16

18.     WHAT DO YOU WANT TO TITLE THE COMBINED STRATA OUTPUT?
        WHITAKER WOODS  1978   STRATIFIED TOTAL   COMPS. 1 - 3

        END OF EXECUTION
        CPU TIME: 4.32  ELAPSED TIME: 5:31.23
        EXIT
```

Answering NO to questions 1 and 4 indicates the user will use the default form classes and the default confidence level of 95 percent.

Question 9 asks the user if heights are total or merchantable and offers three responses: TOTAL, MERCH, or MIXED. The response MIXED would have indicated that softwoods were measured by total height while hardwoods were measured by merchantable height. In this case, however, MERCH was answered indicating merchantable height was used on all trees.

There would be a pause of about thirty seconds between questions 11 and 12 as the program processes stratum 1.

Question 13 asks the user to specify the sampling method as did question 6. However, question 13 offers an additional response: SAME. Answering SAME indicates that in stratum 2 the sampling method, basal area factor, and method of height measurement are identical to those in the previous stratum. Therefore questions 7-10 are not repeated.

Once again there would be a pause of about thirty seconds between questions 14 and 15 and between questions 16 and 17.

Question 18 asks for a title for the combined strata output. This title may be up to 70 characters in length and is printed at the top of each table in the combined strata output section.

After an additional pause of about thirty seconds the end of execution message appears and the output is sent to the line printer queue.

The following example is included to illustrate the alternate form class option and the alternate confidence level option.

```
.RUN INVENT

1.   DO YOU WANT TO READ IN ALTERNATE FORM CLASSES FROM DISK?
     YES

1A.  ENTER FORM CLASS FILE NAME
     WHIT.FRM

1B.  DO YOU WANT A LIST OF THE FORM CLASSES JUST READ?
     YES

WP = 80     RP = 80     PP = 80     HM = 78
BF = 76     TA = 76     SP = 78     NS = 78
SC = 80     CE = 76     OS = 76     SM = 76
RM = 75     WA = 78     WI = 75     AS = 75
YP = 75     BC = 78     WB = 76     YB = 76
SB = 75     GB = 75     BE = 75     BW = 75
RO = 75     WO = 75     BO = 75     EL = 75
GU = 75     HI = 75     HH = 75     OH = 75

2.   ENTER DIAMETER CLASS SIZE
     2

3.   ENTER NUMBER OF STRATA
     3

4.   INVENT USES THE 95% CONFIDENCE LEVEL AS A DEFAULT.
     DO YOU WISH TO USE A DIFFERENT LEVEL?
     YES
4A.  ENTER CONFIDENCE LEVEL AS A DECIMAL IN THE RANGE .65 TO .99
     .90
```

Answering YES to question 1 envokes the alternate form class option. Question 1a asks for the file name while question 1b gives the user the option to list the new form classes. These form classes are the ones described on page 19. Answering YES to question 4 allows the user to specify an alternate confidence level.

SECTION 3. PROGRAM DOCUMENTATION

The FORTRAN program consists of the main program: INVENT; nine subprograms: FRMCLS, LINREG, GUTS, VOLMER, VOLTOT, STRAT, OUTP1, MDSTI, and MDNRIS; and five named common storage areas: COMUNE, FORMCL, REG, OUT1, and STOUT. A description of each along with a variable dictionary are presented below. The program listings are found in Appendix E.

Common Area COMUNE

COMUNE transfers job control information from the main program to the subroutines.

Variable	Type	Dimension	Description
ACRES	Real	-	Acreage of compartment
BAF	Real	-	Prism factor or plot size
CLASIZ	Int	-	Diameter class size
FRAME	Real(C*5)[1]	-	Sampling method
IFILE	D.P.(C*10)	-	Input file name
LOGANS	Int (C*4)	-	Height measurement length technique
MULT	Int	-	Conversion factor to transform logs to feet
PROBLV	Real	-	Two-tailed area under t-curve
REGANS	Int (C*3)	-	Regression option indicator
SAMMTD	D.P.(C*8)	-	Output title indicating sampling method used
TITLE	Int (C*5)	14	Compartment title
TOPANS	Int (C*5	-	Height measurement top technique

Common Area FORMCL

FORMCL transfers the form class array.

Variable	Type	Dimension	Description
FC	Int	32	Form class array

Common Area REG

REG transfers information to and from the regression subroutine.

Variable	Type	Dimension	Description
MEANY	Real	35	Average height
MINDBH	Int	32	Minimum diameter sampled for height
NTR	Int	35	Number of height trees sampled
REGCOF	Real	33	Regression slope
REGINT	Real	33	Regression intercept
RSQR	Real	33	Coefficient of determination
SEREG	Real	35	Standard error of the regression
SPECIE	Int (C*2)	32	Species code
TOTNTR	Int	35	Number of non-cull trees above minimum d.b.h. sampled

[1](C*5) indicates the variable is used to store 5 characters.

Common Area OUT1

OUT1 transfers processed data to the output subroutine.

Variable	Type	Dimension	Description
BASPAC	Real	40,35	Basal area/acre by d.b.h.
BASTOT	Real	35	Basal area/acre
BDTOT	Real	35	Sawlog bd.ft. volume
BDVLSM	Real	40,35	Sawlog bd.ft. volume by d.b.h.
CBTOT	Real	35	Sawlog cub.ft. volume
CBVLSM	Real	40,35	Sawlog cub.ft. volume by d.b.h.
FINPOP	Real	--	Finite population correction
NPNTS	Int	--	Number of sample units sampled
PLTOT	Real	35	Pulpwood cub.ft. volume
PLVLSM	Real	35	Pulpwood cub.ft. volume by d.b.h.
SEBRD	Real	35	Sawlog bd.ft. volume standard error
SECUB	Real	35	Sawlog cub. ft. volume standard error
SEPUL	Real	35	Pulpwood cub.ft. volume standard error
TREPAC	Real	40,35	Trees/acre by d.b.h.
TRETOT	Real	35	Trees/acre
VARBRD	Real	35	Sawlog bd.ft. volume variance
VARPUL	Real	35	Pulpwood cub.ft. volume variance

Note: All volumes are per acre

Common Area STOUT

STOUT transfers combined strata information to the output subroutine.

Variable	Type	Dimension	Description
BDTST	Real	35	Sawlog bd.ft. volume
BDVLST	Real	40,35	Sawlog bd.ft. volume by d.b.h.
CBTST	Real	35	Sawlog cub.ft. volume
CBVLST	Real	40,35	Sawlog cub.ft. volume by d.b.h.
EFDFBD	Real	35	Sawlog bd.ft. volume effective d.f.
EFDFCB	Real	35	Sawlog cub.ft. volume effective d.f.
EFDFPL	Real	35	Pulpwood cub.ft. volume effective d.f.
PLTST	Real	35	Pulpwood cub.ft. volume
PLVLST	Real	40,35	Pulpwood cub.ft. volume by d.b.h.
STSEBD	Real	35	Sawlog bd.ft. volume standard error
STSECB	Real	35	Sawlog cub.ft. volume standard error
STSEPL	Real	35	Pulpwood cub.ft. volume standard error
TACRES	Real	--	Total acres sampled

Note: All volumes are total

Main Program INVENT

INVENT provides interactive user communication and subroutine control. Input and output are to unit 5 which is the user's TTY on the DEC-10. The following job control information is acquired interactively from the user:

(1) Alternate form class specification.

(2) Diameter class size.

(3) Number of strata.

(4) Confidence level.

(5) Input file name.

(6) Sampling method and sampling frame.

(7) Method of height measurement.

(8) Acreage of strata.

(9) Title of combined strata output (if more than one strata).

INVENT opens the output file on unit 3 (LPT on DEC-10) naming it INVENT.LPT. INVENT also sets the default confidence level to 95 percent.

The following subroutine calls are made in INVENT: FRMCLS, LINREG, GUTS, OUTP1, OUTP2, STRAT, and STRAT2.

Common Area Used: COMUNE.

Other Variables	Type	Dimension	Description
ALPHA	Real	--	Confidence level as a decimal
ALPHCH	Real(C*3)	--	Confidence level change flag
FRMANS	Real(C*3)	--	Form class change flag
III	Int	--	Loop counter for strata number
ISTRAT	Int	--	Number of strata
REPEAT	D.P.(C*8)	--	User message
SVFRAM	Real(C*5)	--	Saves the contents of FRAME

Subroutine FRMCLS

FRMCLS is called by INVENT if the user specifies that he wishes to use alternate form classes. FRMCLS interactively asks the user to specify the name of the file where the alternate form classes are stored. This file is read from unit 1 (disk on DEC-10). As in INVENT, unit 5 is used to communicate with the user. The user is given the option to list the new form classes after they are read from the file.

Common Areas Used: FORMCL and REG.

Other Variables	Type	Dimension	Description
FCFILE	D.P.(C*10)	--	Input file name
I	Int	--	Implied do loop index
LSTANS	Int	--	Form class list option flag

Subroutine LINREG

LINREG is called by INVENT if the user specifies that only the heights of a subsample of the volume trees were measured. LINREG then reads through

the data file specified by the variable IFILE and located on unit 21 (disk on DEC-10). For every species with three or more height trees measured, LINREG fits the following regression model: HEIGHT = B_0 + B_1 * 1/DBH. The following statistics are calculated and stored in common area REG:

(1) Regression intercept.

(2) Regression slope.

(3) Standard error of the regression.

(4) Number of height trees measured.

(5) Total number of merchantable trees sampled.

(6) Average height.

(7) Coefficient of determination (R^2).

(8) Minimum diameter of all height trees sampled if less than 8 inches.

LINREG ignores cull trees (HEIGHT = 999). It also checks that input parameters are within the following ranges:

$1 \leq DBH \leq 40$ $0 \leq HEIGHT \leq 7$ if height measured by logs.

$0 \leq HEIGHT \leq 200$ if height measured in feet.

If data is found outside these ranges, the value is set to the minimum or maximum of the range. If an illegal species code appears, the tree is ignored and an error message is written to unit 5.

LINREG also calculates certain statistics for the Softwood, Hardwood and All Species accumulations. These statistics include (3), (4), (5) and (6) above.

Common Area Used: REG.

Other Variables	Type	Dimension	Description
CORMNY	Real	--	Corrected mean height for species
CORNTR	Real	--	Corrected number of trees sampled
COVXY	Real	33	Covariance of X and Y
DBH	Int	--	Diameter at breast height
HEIGHT	Real	--	Tree height
IDUMMY	Int	--	DO loop index for reps on input
IREP	Int	--	Number of reps on input
ISPEC	Int	--	Species loop counter
ITYPE	Int	--	Forest type code
JTYPE	Int	--	Forest type code
LOOP	Int	--	Loop counter
MEANX	Real	35	Mean of X
MEANY	Real	35	Mean of Y
MNYCOR	Real	3	Corrected mean height for forest types

Other Variables	Type	Dimension	Description
MSE	Real	--	Mean square error
NTRCOR	Int	3	Corrected number of trees for forest type
NUMREG	Int	3	Number of regressions run
POINT	Int	--	Point number
SPEC	Int(C*2)	--	Species input code
SSE	Real	--	Sum of the squares of error
TREES	Int	--	Number of trees on a sample unit
TYPSSE	Real	3	Forest type error sum of squares
VARX	Real	33	Variance of X
VARY	Real	33	Variance of Y
X	Real	33	1/D.B.H.
XSUM	Real	33	Sum of X
XSUMSQ	Real	33	Sum of X^2
Y	Real	33	Height
YSUM	Real	35	Sum of Y
YSUMSQ	Real	33	Sum of Y^2

Subroutine GUTS

GUTS is called by INVENT to read the input data and calculate the basal area per acre, trees per acre, and all of the volumes along with their standard errors. GUTS also calculates the number of units sampled and the percent cruise. Either subroutine VOLMER or VOLTOT is called by GUTS repeatedly to calculate tree volume.

GUTS reads the input file specified by the variable IFILE and located on unit 21 (disk on DEC-10). It checks the range of input data in the same way LINREG does except that the minimum allowed DBH is set at the value of CLASIZ instead of 1.

GUTS checks the value of POINT on the first plot to see if POINT = -9. Such a value indicates the data is presented in summary mode (not tallied by individual plot) and therefore no statistical analysis of the sampling error can be made. It also indicates that the value of TREES is the number of plots sampled.

GUTS reads all the data accumulating sums of basal areas, number of trees, sawlog board foot volume, sawlog cubic foot volume, and pulpwood cubic foot volume. After all the data is read, the accumulated sums are expanded into per acre estimates based on the sampling technique used (point or plot). The variances and standard errors of these volumes are also calculated. Before

attempting to calculate variances, GUTS checks to see if more than one plot has been sampled. If not, GUTS sets itself into summary mode and does not attempt to calculate any variances or standard errors.

Common Areas Used: COMUNE, REG, and OUT1.

Other Variables	Type	Dimension	Description
DBVOL	Real	--	Board foot volume of a tree
BRDPT	Real	35	Sawlog bd.ft. volume of a sample unit
BRDSQ	Real	35	Sum of $BRDPT^2$
CUBPT	Real	35	Sawlog cub.ft. volume of a sample unit
CUBSQ	Real	35	Sum of $CUBPT^2$
CUBVOL	Real	--	Cubic foot volume of a tree
DBH	Int	--	Diameter at breast height
FACTOR	Real	--	Sample method expansion factor
HEIGHT	Real	--	Tree height
I	Int	--	DO loop index
IREP	Int	--	Number of reps on input
ISPEC	Int	--	Species loop counter
ISTART	Int	2	First of a forest type
ISTOP	Int	2	Last of a forest type
LOOP	Int	--	Loop counter
NPLOTS	Int	--	Number of plots sampled
PCTCRZ	Real	--	Percent cruise
PCTSAW	Real	--	Percent sawlog
PLTSIZ	Real	--	Fixed radius plot size
POINT	Int	--	Point number
PROD	Real(C*1)	--	Product code
PULPT	Real	35	Pulpwood cub.ft. volume of a sample unit
PULSQ	Real	35	Sum of $PULPT^2$
PULVOL	Real	--	Pulpwood cub.ft. volume of a tree
REGWGT	Real	--	Weight for regression standard error
SPEC	Int(C*2)	--	Species input code
TRECNT	Int	40,32	Number of trees tallied by d.b.h.
TREES	Int	--	Number of trees on a sample unit
VARCUB	Real	--	Sawlog cub.ft. volume variance

Subroutine VOLMER

VOLMER is called by GUTS to calculate the merchantable cubic and board foot volume of individual trees when tree height is specified to a merchantable top. The input parameters are d.b.h., merchantable height, and species.

The cubic foot volume equations are from Barnard et al. (1969). To use these equations all species must be placed in one of seventeen groups. The species grouping is as follows:

Species Group Number	Species in Group
1	WP, RP, OH
2	SP
3	BF
4	HM
5	PP, TA, NS, SC
6	CE
7	SM
8	RM, YP
9	WA, AS
10	BC
11	WB, YB, SB, GB
12	BE
13	B
14	RO, BO, GU
15	WO, EL
16	HI
17	WI, HH, OH

The board foot volume equation is from Wiant and Castenada (1977). This equation is a formulation of the Mesavage and Girard (1946) form class tables. A form class must be specified for each of the 32 species. VOLMER sets the form classes to the following defaults:

Hemlock	70
All other softwoods	76
All hardwoods	74

The user can specify alternate form classes at execution time.

The cubic foot equations are based on a 4" merchantable top while the board foot equations are based on a 10" merchantable top. The equations are presented in full in Appendix C, pages 56 and 57.

Common Area Used: FORMCL.

Other Variables	Type	Dimension	Description
BDHT	Real	--	Board ft. merchantable height in logs
BDVOL	Real	--	Board ft. volume of tree
CBHT	Real	--	Cubic ft. merchantable height in feet
CUBINT	Real	17	Cubic ft. volume equation intercept
CUBSLP	Real	17	Cubic ft. volume equation slope
CUBVOL	Real	--	Cubic ft. volume of tree
DBH	Int	--	Diameter at breast height
GRP	Int	32	Species group for cub.ft. volume equation
HEIGHT	Real	--	Tree height
I	Int	--	Implied DO loop index for data statements
ISPEC	Int	--	Species loop counter
WIANT	Real Function		Computes board foot volume

Subroutine VOLTOT

VOLTOT is called by GUTS to calculate the merchantable cubic and board foot volume of individual trees when total tree height is measured. The input parameters are d.b.h., total height, and species.

Both the cubic and board foot equations are from Honer (1967). In applying these formulas, the gross cubic foot volume of the tree is first calculated. The merchantable cubic and board foot volumes are then derived from the gross volume. To use these equations it is necessary to place all species into one of 16 groups. The species grouping is as follows:

Species Group Number	Species in Group
1	WP
2	RP, PP, TA, SC, OS
3	SP, NS
4	BF
5	CE
6	HM
7	AS
8	WB, SB, GB
9	YB
10	SM, RM, YP
11	BW
12	BE
13	BC
14	EL
15	WI, HH, OH
16	RO, WO, BO GU, HI, WA

Stump height and merchantable top are variables in the equations. VOLTOT sets these to the following defaults:

Stump Height	0.5 ft.
Cubic Foot Top	4 in.
Softwood Board Foot Top	6 in.
Hardwood Board Foot Top	8 in.

The equations are presented in full in Appendix C, page 58.

No common area used.

Variables	Type	Dimension	Description
ASDRBF	Real	3	Board foot volume equation coefficients
ASDRCF	Real	3	Cubic foot volume equation coefficients
BDVOL	Real	--	Sawlog bd.ft. volume of tree
BRDTOP	Real	2	Bd.ft. merchantable top diameter
CUBINT	Real	16	Cub.ft. volume equation intercept
CUBSLP	Real	16	Cub.ft. volume equation slope
CUBTOP	Real	2	Cub.ft. merchantable top diameter
CUBVOL	Real	--	Cubic ft. volume of tree
DBH	Int	--	Diameter at breast height
GRP	Int	32	Species group for volume equations
HEIGHT	Real	--	Tree Height
I	Int	--	Implied DO loop index for data statements
ISPEC	Int	--	Species loop counter
ITYPE	Int	--	Forest type indicator
STUMP	Real	--	Stump height
TCBVOL	Real	--	Total cubic foot volume
XBRD	Real	--	Intermediate step in bd.ft. volume calculation
XCUB	Real	--	Intermediate step in cub.ft. volume calculation

Subroutine STRAT

STRAT is called by INVENT if more than one stratum are being processed. STRAT calculates combined strata statistics for sawlog cubic foot volumes, sawlog board foot volumes and pulpwood cubic foot volumes. These statistics include total volume over all strata along with their standard error and effective degrees of freedom. STRAT also calculates the total acreage of all the strata combined.

STRAT has two entry points, STRAT and STRAT2. STRAT is used as an entry point after each individual stratum is processed. Sums are accumulated for volumes, variances, and squared variances. STRAT2 is called after all of the strata have been processed. The previously accumulated sums are used to calculate total volumes, standard errors, and effective degrees of freedom.

Common Areas Used: OUT1 and STOUT.

Other Variables	Type	Dimension	Description
ACRES	Real	--	Acreage of compartment
CLASIZ	Int	--	Diameter class size
DBH	Int	--	Diameter at breast height
DFBD2	Real	32	Intermediate calculation in EFDFBD
DFCB2	Real	32	Intermediate calculation in EFDFCB
DFPL2	Real	32	Intermediate calculation in EFDFPL
ISPEC	Int	--	Species loop counter
STVMBD	Real	35	Sawlog bd.ft. variance
STVMCB	Real	35	Sawlog cub.ft. variance
STVMPL	Real	35	Pulpwood cub.ft. variance
I	Int	--	Implied DO loop index
J	Int	--	Implied DO loop index

Subroutine OUTP1

OUTP1 is called by INVENT to produce all of the program's output. The subroutine has two entry points, OUTP1 and OUTP2. OUTP1 is used to produce the individual stratum output while OUTP2 is used to produce the stratified total output. All output is written to unit 3 (LPT on DEC-10) creating a file named INVENT.LPT.

OUTP1 produces the following output tables for each stratum:

1. Summary of job control related information (Table 1).
2. Analysis of the height-dbh relationship if regression option used (Table 17).
3. Individual stand and stock table for each species sampled (Tables 2, 3).
4. Stand and stock tables for Softwood summary, Hardwood summary, and All Species summary (Tables 4, 5, 6).
5. Table of species composition by percent (Table 7).
6. Table of volume totals for all species (Table 8).
7. Table of volume totals for all species expanded by acreage (Table 9).

The stand and stock tables include basal area/acre, trees/acre, sawlog cubic and board foot volumes per acre, and pulpwood cubic foot volume per acre, all presented by diameter class as well as a total over all diameters. A confidence interval expressed as a percent is given for each volume total. Also listed are mean stand diameter, merchantable m.s.d. (mean stand diameter of trees with dbh greater than or equal to 8 inches), percent cruise, sawlog board foot coefficient of variation, and pulpwood cubic foot coefficient of variation. Furthermore, the title of each compartment is printed on the top of each page and the pages are consecutively numbered.

OUTP2 is used as an entry point to produce the following stratified total output if more than one stratum were sampled:

1. Summary of job control related information (Table 10).
2. Volume tables for each species sampled (Table 11, 12).
3. Volume tables for Softwood summary, Hardwood summary, and All Species summary (Tables 13-15).
4. Table of volume totals for all species (Table 16).

All volume figures from OUTP2 are total volumes expanded over the entire acreage of all the strata combined. The individual species tables and the three summary tables list volumes by diameter class as well as giving a total over all diameters. A confidence interval expressed as a percent is given for each volume total. Each page of the output is consecutively numbered and a specified title is printed at the top of each page.

Both OUTP1 and OUTP2, when producing individual species tables, will print the form class used to calculate board foot volume next to the species title if the trees were measured to a merchantable top. Otherwise, no form class information is printed.

Common Areas Used: COMUNE, FORMCL, OUT1, REG, and STOUT.

Other Variables	Type	Dimension	Description
AFCNUM	Real(C*2)	--	Form class number as a literal
AFCTIT	Real(C*5)	--	Output title
ALPHA	Real	--	Confidence level as a decimal
BASCOM	Real	--	Percentage of basal area
BDCOM	Real	--	Percentage of sawlog bd.ft. volume
CUBCOM	Real	--	Percentage of sawlog cub.ft. volume
DBH	Int	--	Diameter at breast height
DF	Real	--	Degrees of freedom
I	Int	--	Implied DO loop index for data statements
IBDCV	Int	--	Board ft. coefficient of variation
IBDTST	Int	--	Total sawlog bd.ft. volume all strata
IBDVST	Int	--	Total sawlog bd.ft. volume all strata by dbh
ICBTST	Int	--	Total sawlog cb.ft. volume all strata
ICBVST	Int	--	Total sawlog bd.ft. volume all strata by dbh
IDATE	Int(C*5)	2	Date
IERBRD	Int	--	Percent error in sawlog bd.ft. volume
IERCUB	Int	--	Percent error in sawlog cb.ft. volume
IERPUL	Int	--	Percent error in pulpwood cb.ft. volume
IFLAG	Int	--	Warning message flag
IPAGE	Int	--	Page number
IPLCV	Int	--	Pulpwood coefficient of variation
IPLTST	Int	--	Total pulpwood cb.ft. volume all strata
IPLVST	Int	--	Total pulpwood cb.ft. volume all strata by dbh
ISPEC	Int	--	Species loop counter
ISTRA	Int	--	Number of strata sampled
J	Int	--	Implied DO loop index
MSD	Real	--	Mean stand diameter
OFRAME	Real(C*5)	--	Saves the contents of FRAME
PCTCRZ	Real	--	Estimated percent cruise for point sampling
PULCOM	Real	--	Percentage of pulpwood volume
RBSTOT	Real	--	Basal area of trees with dbh $\leq$ 8"
REGUSE	Real(C*4)	--	Output message
RMSD	Real	--	Merchantable mean stand diameter
RTRTOT	Real	--	Trees/acre of trees with dbh $\leq$ 8"
SPETIT	Int(C*5)	35,3	Species titles for output

Other Variables	Type	Dimension	Description
TOTABD	Int	--	Total sawlog bd.ft. volume
TOTACB	Int	--	Total sawlog cb.ft. volume
TOTAPL	Int	--	Total pulpwood volume
TOTPTS	Int	--	Total number of sample units
TRECOM	Real	--	Percentage of trees/acre
TVAL	Real	--	t-value

Subroutines MDSTI and MDNRIS

MDSTI and MDNRIS are adapted from the International Mathematical and Statistical Libraries, Inc. (IMSL). Both subroutines have been edited removing capabilities not needed in this application. The remaining code is reproduced in Appendix E in accordance with the IMSL policy on research work as stated on page INTRO-22 of the July, 1977 IMSL library manual.

MDSTI is called by OUTP1 to calculate the percentage point of the Student's t distribution. MDNRIS is called by MDSTI and is used to evaluate the inverse normal probability distribution function. MDSTI gives 5 significant digit accuracy (IMSL 1977). Furthermore, table 26.10, p. 999 of the Handbook of Mathematical Functions edited by Abramowitz and Stegun was duplicated by MDSTI (IMSL 1977).

No variable dictionary is presented. The interested reader may refer to pages MDSTI-1, MERFI/MERFCI/MDNRIS-1, and MERFI/MERFCI/MDNRIS-2 of the 1977 IMSL Library manual.

SECTION 4. STATISTICAL ANALYSIS

Overview

The purpose of INVENT's statistical analysis is to indicate the reliability of the volume estimates. This is accomplished by computing a confidence interval for all volume estimates that are summed across the diameter classes. This confidence interval is specified as a percent of the respective volume estimate. The user specifies the confidence level as a decimal in the range .65 to .99. All statistical analysis assumes a stratified random sample where each sample unit is a cluster. There is an option to double sample for height within the clusters.

INVENT calculates confidence intervals for sawlog cubic foot volume, sawlog board foot volume, and pulpwood cubic foot volume. The analysis for each volume is carried out independently of the other volumes. Since the method is exactly the same for each volume, the calculation of error for an arbitrary volume V is presented. Throughout the discussion we will assume the reader is familiar with the techniques for calculating the mean volume per acre when the heights of all volume trees are measured. (Cf. Barrett and Nutt, 1975; Avery, 1975; Husch, Miller, and Beers, 1972; Dillworth and Bell, 1976.)

The statistical analysis is presented in the same sequence as the program performs it. For each individual stratum the standard error of the volume must be calculated. If the height subsampling option is used, the program first calculates the standard error due to height estimation. Next the percent cruise of the stratum is calculated. This is used to refine the standard error due to the variation between clusters which is calculated next. This standard error is then combined with the height estimation standard error to give the volume standard error of the stratum. Finally, the volume standard errors of all the strata are combined to yield the standard error of the stratified volume estimate along with the effective degrees of freedom of that estimate.

Standard Error of Height Estimation

INVENT allows the user to double sample within each cluster for tree height. For each species where three or more height trees are measured within the stratum, a regression relationship between height and the inverse of d.b.h. is analysed. When calculating volume for a tree whose height was not measured, the regression equation is used to generate a height for that tree. If the user were required to measure the heights of all trees on some of the clusters while measuring no heights on the remaining clusters, the volume standard error could be calculated using techniques developed by Donald Bruce (1961) and Floyd A. Johnson (1958). Bruce's method is outlined in Appendix B, page 53. Johnson's method is an application of double sampling with ratio of means estimation and this method is presented in Appendix B, page 52. Neither method is applicable if the user is free to subsample a portion of the trees within each cluster. A new statistical technique was developed to approximate the standard error of the resulting volume estimate.

The authors believe that this new technique is far more efficient in field application. It allows the user to sample heights more intensely on the more valuable species. It provides far more flexibility than the traditional approach.

H = height D = d.b.h. T = # trees sampled t = # height trees sampled

Regression Model: $H = B_0 + B_1 \left(\frac{1}{D}\right) + \varepsilon$

$$\text{Variance (H)} = S_H^2 = \frac{MSE}{t}$$

where MSE = mean square error of the regression (for computational formula see Neter and Wasserman, 1974, p. 45).

$$\text{Standard Error (H)} = SE_H = \frac{S_H}{\bar{H}} (100)$$

SE_H is calculated for every species where three or more height trees are measured. It is also necessary to calculate SE_H for the Softwood, Hardwood and All Species summary volumes. The method used is from Neter and

Wasserman pp. 163-4 (1974). It is equivalent to fitting a regression for each of the three groups using pooled data from each species in the group. However the method used is far more efficient. We simply define T^*, t^*, and MSE^* for each summary group as a function of T, t, and MSE for every species in that group. For instance, suppose we want SE_H for hardwoods where the hardwood group in this stratum consists of three species. Then,

$$T^* = T_1 + T_2 + T_3$$

$$t^* = t_1 + t_2 + t_3$$

$$MSE^* = \frac{MSE_1(t_1-2) + MSE_2(t_2-2) + MSE_3(t_3-2)}{(t_1-2) + (t_2-2) + (t_3-2)}$$

Using these new values, SE_H is calculated as before.

Percent Cruise

Percent cruise is simply the percent of the population actually sampled. When sampling with fixed-radius plots, percent cruise is easily calculated as follows:

Let P = percent cruise
PLT = plot size in acres
n = number of plots sampled
AC = tract size in acres

Then, $P = \frac{n \cdot PLT}{AC} \quad (100)$

When sampling with variable-radius plots (point sampling) the true value of P is unknown. However, based on our sample estimate of MSD we can estimate the value of P (Cunia, 1959).

Let P = percent cruise
n = number of sample points
AC = tract size in acres
BAF - basal area factor of angle used
B = total basal area of all trees on tract
T = total number of trees on tract
MSD = mean stand diameter (quadratic mean)

Then, $P = \frac{100 \cdot n \cdot B}{T \cdot AC \cdot BAF} = \frac{0.5454 \cdot n \cdot MSD^2}{AC \cdot BAF}$

It should be noted that in a variable-radius cruise, the percent cruise may be different for each species. See tables 2 and 3.

In forest sampling, we deal with finite populations. The formula we use to estimate the variance of the mean volume per acre for each stratum includes a term known as the finite population correction (FPC). The FPC reduces the variance of the mean when a significant (usually > 5 percent) portion of the population has been sampled.

Let N = number of sample units in population

n = number of units actually sampled

Then, $FPC = \frac{N - n}{N}$

In plot sampling $N = \frac{AC}{PLT}$ and n = number of plots sampled. However, in point sampling there is no easy was to calculate N. Therefore, mensurationists have traditionally ignored the FPC when analysing point cruises. This can be quite inefficient when tract sizes are small as is often the case in New Hampshire. This problem can be easily overcome using the previous result permitting the calculation of percent cruise when point sampling. It can easily be shown that the FPC is simply a function of P (percent cruise).

$$FPC = \frac{N - n}{N} = \frac{N}{N} - \frac{n}{N} = 1 - \frac{n}{N} = 1 - \frac{P}{100}$$

INVENT uses this relationship to refine the variance estimates when point sampling as well as plot sampling. INVENT calculates FPC as $1 - \frac{P}{100}$.

The standard error due to the variation in volume between clusters, $SE_{\bar{Y}}$, is calculated as follows:

$\bar{Y}$ = mean volume/acre of stratum

S^2 = sample variance of volume

n = number of sample units

then, $SE_{\bar{Y}} = \sqrt{\frac{S^2}{n}} \left[\frac{1}{\bar{Y}}\right] (100) \quad (FPC)$

If the height of all volume trees was measured, then $SE_{\bar{Y}}$ is the standard error of the volume estimate for the stratum, SE_{VOL}. If, however, the

height double sampling option was used, SE_{VOL} must reflect both $SE_{\bar{Y}}$ and SE_H, the standard error due to height estimation. In this case, SE_{VOL} is calculated as follows:

$$SE_{VOL} = \sqrt{SE_{\bar{Y}}^2 + \frac{(T - t)}{T} (SE_H^2)}$$

Combined Strata Statistics

We have seen how INVENT calculates the mean volume/acre with its standard error for each stratum in the sample. The final step in the statistical analysis is to use the individual stratum statistics to calculate the total volume across all strata along with the standard error.

Let L = number of strata sampled

AC_i = size of stratum i in acres

N_i = number of sample units in stratum i

n_i = number of units sampled in stratum i

$\bar{Y}_i$ = mean volume per acre of stratum i

VOL_i = total volume of stratum i = $AC_i \cdot \bar{Y}_i$

SE_{VOL_i} = volume standard error of stratum i as a percent

$S^2_{VOL_i} = (SE^2_{VOL_i} \cdot VOL_i^2) / 100^2$ = variance of total volume

then we calculate the stratified total statistics as follows:

$$AC = \sum_{i=1}^{L} AC_i = \text{total acreage sampled}$$

$$VOL = \sum_{i=1}^{L} VOL_i = \text{stratified total volume}$$

$$SE_{VOL} = \frac{\sqrt{\sum_{i=1}^{L} S^2_{VOL_i}}}{VOL} (100)$$

Having calculated VOL and SE_{VOL}, all that remains in calculating the confidence interval is determining the appropriate percentage point of the Student's t distribution. In order to do this we must calculate the degrees of freedom associated with S^2_{VOL}. Satterthwaite (1946) states that the exact distribution of the complex estimate S^2_{VOL} is too involved for

everyday use. He suggests approximating the true distribution with a Chi-square distribution of equal variance. Cochran (1977 p. 96) uses this approach and defines the degrees of freedom of the approximating Chi-square as:

$$DF_{eff} = \frac{\left[\sum_{i=1}^{L} g_i S_i^2\right]^2}{\sum_{i=1}^{L} \frac{g_i^2 S_i^4}{n_i - 1}} \qquad \text{where } g_i = \frac{N_i (N_i - n_i)}{n_i}$$

S_i^2 = sample variance

A more appropriate form for our purposes is given by

$$DF_{eff} = \frac{\left[\sum_{i=1}^{L} S^2_{VOL_i}\right]^2}{\sum_{i=1}^{L} \frac{S^4_{VOL_i}}{n_i - 1}}$$

The equivalence of the two formulas is shown in Appendix B, page 54.

Using this result the appropriate value t is derived from the Student's t distribution and the confidence interval is given by:

$$VOL \pm t \cdot SE_{VOL}$$

APPENDIX A

DATA CODING INFORMATION

EXAMPLES OF TREE CODING OPTIONS

Column:	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		SPECIE CODE		DIAMETER		PRODUCT CODE		HEIGHT			REPLICATIONS			PERCENT SAWLOG
Sawlog only Height in logs	W	P		1	6	S	2	.	0		2			
Sawlog only Height in feet	R	P		1	8	S		4	8		1			
Pulpwood only Height in feet	B	E		1	0	P		2	0		1			
Mixed product Height in logs	R	O		1	6	%	2	.	0		3		5	0
Mixed product Height in feet	S	P		2	2	%		6	4		1		6	0
Sawlog only Height in logs Default specification of reps and product.	H	M		1	2		1	.	0					

INVENT Species List

White Pine	WP
Red Pine	RP
Pitch Pine	PP
Hemlock	HM
Balsam Fir	BF
Tamarack	TA
Spruce	SP
Norway Spruce	NS
Scotch Pine	SC
Cedar	CE
Other Softwoods	OS
Sugar Maple	SM
Red Maple	RM
Ash	WA
Willow	WI
Aspen	AS
Yellow Poplar	YP
Black Cherry	BC
White Birch	WB
Yellow Birch	YB
Sweet Birch	SB
Grey Birch	GB
Beech	BE
Basswood	BW
Red Oak	RO
White Oak	WO
Black Oak	BO
Elm	EL
Gum	GU
Hickory	HI
Hophornbeam	HH
Other Hardwoods	OH

INVENT TALLY SHEET

COMP. 1

POINT 1 # TREES 11

SPECIES	DBH	HEIGHT	PRODUCT	#
RP	14	3.0		
WP	20	4.0		
RP	14	3.5		
WP	18	4.0		
WP	12	3.0		
WP	18	3.5		
WP	16	3.0		
WP	20	4.0		
WP	22	4.5		
WP	22	4.5		
RP	16	3.0		

COMP. 1

POINT 2 # TREES 12

SPECIES	DBH	HEIGHT	PRODUCT	#
WP	12	2.5		
WP	20	3.5		
WP	32	4.0		
RP	16	3.0		
BE	10	1.0		
BE	06	.5	P	2
WP	16	3.5		
WP	16	4.0		
WP	12	2.0		
RP	16	3.0		
WP	26	4.0		

COMP. 1

POINT 3 # TREES 9

SPECIES	DBH	HEIGHT	PRODUCT	#
WP	26	4.0		
WP	32	4.5		
RP	22	3.5		
RP	18	3.5		
RO	14	1.0		
RO	22	1.0		
RO	18	1.0		
WP	26	5.0		2

COMP. 1

POINT 4 # TREES 14

SPECIES	DBH	HEIGHT	PRODUCT	#
WP	22	4.0		
WP	30	4.0		
WP	30	4.0		
WP	20	3.5		
WP	20	4.0		2
WP	26	4.5		
WP	16	4.0		
WP	18	4.5		
WP	18	3.0		
WP	20	4.5		
WP	28	4.5		
WP	32	4.0		
WP	20	4.5		

INVENT DATA FILE

```
WHITAKER WOODS  1978   COMP. 1
01 11
RP 14 3.0
WP 20 4.0
RP 14 3.5
WP 18 4.0
WP 12 3.0
WP 18 3.5
WP 16 3.0
WP 20 4.0
WP 22 4.5
WP 22 4.5
RP 16 3.0
02 12
WP 12 2.5
WP 20 3.5
WP 32 4.0
RP 16 3.0
BE 10 1.0
BE 06P0.5 2
WP 16 3.5
WP 16 4.0
WP 12 2.0
RP 16 3.0
WP 26 4.0
03 09
WP 26 4.0
WP 32 4.5
RP 22 3.5
RP 18 3.5
RO 14 1.0
RO 22 1.0
RO 18 1.0
WP 26 5.0 2
04 14
WP 22 4.0
WP 30 4.0
WP 30 4.0
WP 20 3.5
WP 20 4.0 2
WP 26 4.5
WP 16 4.0
WP 18 4.5
WP 18 3.0
WP 20 4.5
WP 28 4.5
WP 32 4.0
WP 20 4.5
05 13
WP 24 3.0
RP 16 2.0
WP 32 4.0
WP 26 3.5
RO 12 1.0
HM 18 1.5
HM 16 1.0
RP 12 1.0
RP 10 1.0
RO 16 1.0 2
WP 14 2.5
HM 18 2.0
```

INVENT Processing Request Form

Forester Information:

Name:_____

Firm Name:_____

Address:_____

_____

Tract Information:

Number of compartments:_____

Do you wish to use alternate form classes? _____ (yes or no)

If yes enter form classes below.

WP_____ RP_____ PP_____ HM_____ BF_____ TA_____ SP_____ NS_____

SC_____ CE_____ OS_____ SM_____ RM_____ WA_____ WI_____ AS_____

YP_____ BC_____ WB_____ YB_____ SB_____ GB_____ BE_____ BW_____

RO_____ WO_____ BO_____ EL_____ GU_____ HI_____ HH_____ OH_____

Diameter class size_____

INVENT uses the 95% confidence level as a default. If you wish to use a different level, please specify _____ (65 - 99)

Tract Description (up to 70 characters)

: _____

INVENT Compartment Information Form

Compartment Name and/or Description (up to 70 characters)

: _____

Sampling Method _____ (Point, Plot, Strip, or 100%)

If Point: BAF = _____

If Plot : Plot size = _____ acres

If Strip: Total acreage of all strips = _____ acres

Tree Height Measurement Units _____ (16 ft. logs or feet)

Tree top specification _____ (merchantable, total, or mixed)

Were the heights of all volume trees measured? _____ (yes or no)

Acreage of compartment: _____ acres

APPENDIX B

STATISTICAL FORMULAS AND DERIVATIONS

DOUBLE SAMPLING WITH RATIO OF MEANS EXPANSION

X_i = Basal area per acre at cluster i

Y_i = Volume per acre at cluster i_j

N = Number of possible sample units

n = Total number of units sampled

n_o = Number of volume units sampled

$\overline{X}$ = Average basal area of all units sampled

$\overline{X}_o$ = Average basal area of the volume units sampled

$\overline{Y}_o$ = Average volume of the volume units sampled

$\overline{Y}_r$ = Ratio estimate of the mean volume per acre

$$B = \frac{\overline{Y}_o}{\overline{X}_o}$$

$$\overline{Y}_r = B \cdot \overline{X}$$

$$S^2_{\overline{Y}_r} = \left(\frac{n_o - n}{n_o}\right)\left(\frac{\overline{X}_o}{\overline{X}}\right)^2 \left(\frac{S_Y^2 + B^2 S_X^2 - 2BS_{XY}}{n}\right) + \frac{S_Y^2}{n_o}\left(\frac{N - n_o}{N}\right)$$

STATISTICAL ANALYSIS OF A VARIABLE PLOT CRUISE USING BRUCE'S METHOD

(Bruce 1961)

Notation

γ - volume points

α - all points

n - number of points

TC - tree count

VBAR - volume to basal area ratio

VOL - volume per acre

SE - standard error expressed as a percent

CF - correction factor

Example of Notation:

SE_{TC_α} - standard error of the tree count on all points expressed as a percent

$$\text{Estimated volume} = VOL_\gamma \cdot \left[\frac{TC_\alpha / n_\alpha}{TC_\gamma / n_\gamma} \right] = (VOL_\gamma \cdot TC_\alpha \cdot n_\gamma)/(TC_\gamma \cdot n_\alpha)$$

$$\text{Uncorrected standard error} = \sqrt{SE^2_{VBAR_\gamma} + SE^2_{TC_\alpha}}$$

Corrected standard error = CF·(uncorrected standard error)

$$\text{where CF} = \frac{SE_{VOL_\gamma}}{\sqrt{SE^2_{VBAR_\gamma} + SE^2_{TC_\gamma}}}$$

FORMULA FOR EFFECTIVE DEGREES OF FREEDOM

$$DF_{eff} = \frac{\left(\sum_{i=1}^{L} g_i S_i^2\right)^2}{\sum_{i=1}^{L} \frac{g_i^2 S_i^4}{n_i - 1}} \qquad \text{where } g_i = \frac{N_i\,(N_i - n_i)}{n_i}$$

$$= \frac{\left(\sum_{i=1}^{L} \frac{N_i\,(N_i - n_i)}{n_i}\, S_i^2\right)^2}{\sum_{i=1}^{L} \frac{\left(\frac{N_i\,(N_i - n_i)}{n_i}\right)^2 S_i^4}{n_i - 1}}$$

$$= \frac{\left(\sum_{i=1}^{L} \frac{S_i^2}{n_i} \cdot \frac{(N_i - n_i)\,N_i^2}{N_i}\right)^2}{\sum_{i=1}^{L} \frac{\left(\frac{S_i^2}{n_i} \cdot \frac{(N_i - n_i)}{N_i}\right)^2 N_i^4}{n_i - 1}}$$

$$= \frac{\left(\sum_{i=1}^{L} S_{\bar{Y}_i}^2 \cdot N_i^2\right)^2}{\sum_{i=1}^{L} \frac{S_{\bar{Y}_i}^4 \cdot N_i^4}{n_i - 1}} = \frac{\left(\sum_{i=1}^{L} S_{VOL}^2\right)^2}{\sum_{i=1}^{L} \frac{S_{VOL}^4}{n_i - 1}}$$

APPENDIX C

VOLUME FORMULAS

CUBIC FOOT VOLUME EQUATIONS

BASED ON MERCHANTABLE HEIGHT

(Barnard et al. 1973)

General form of equation: $VOLUME = a + b\ (DBH^2 \cdot HEIGHT)$

where height is measured to a 4" top in ft.

Species Group	a	b
1	3.5142	0.00236
2	2.1998	.00257
3	1.4793	.00272
4	2.4784	.00242
5	-0.0496	.00303
6	1.5817	.00259
7	1.6823	.00310
8	1.1763	.00310
9	1.0067	.00293
10	1.1809	.00292
11	1.1339	.00281
12	1.2851	.00326
13	0.8976	.00349
14	1.2027	.00301
15	1.0009	.00300
16	1.4438	.00316
17	0.8591	.00309

For the species composition of each group see page 31.

BOARD FOOT VOLUME EQUATION

BASED ON MERCHANTABLE HEIGHT

(Wiant and Castenada 1978)

(INT. 1/4-inch Rule)

D = diameter at breast height

H = merchantable height to a 10" top in 16 foot logs

FC = Girard form class

$$VOLUME = [(a_0+a_1H+a_2H^2) + (b_0+b_1H+b_2H^2)D + (c_0+c_1H+c_2H^2)D^2] \quad [(FC-78)(.03)+1]$$

where $a_0 = -13.35212$

$a_1 = 9.58615$

$a_2 = 1.52968$

$b_0 = 1.79620$

$b_1 = -2.59995$

$b_2 = -0.27465$

$c_0 = 0.04482$

$c_1 = 0.45997$

$c_2 = -0.00961$

CUBIC AND BOARD FOOT VOLUME EQUATIONS

BASED ON TOTAL HEIGHT

(Honer 1967)

(INT. 1/4-inch Rule)

D = diameter at breast height
H = total height in feet
GCVL = gross cubic foot volume
MCVL = merchantable cubic foot volume
MBVL = merchantable board foot volume
STH = stump height
CTOP = cubic foot merchantable top diameter
BTOP = board foot merchantable top diameter

Equations:

$$GCVL = \frac{D^2}{a_0 + \frac{a_1}{H}}$$

$$X = \left[\frac{CTOP^2}{D^2}\right] \left[\frac{H + STH}{H}\right]$$

$$MCVL = [b_o + b_1 X + b_2 X^2] \cdot GCVL$$

$$Y = \left[\frac{BTOP^2}{D^2}\right] \left[\frac{H + STH}{H}\right]$$

$$MBVL = [c_o + c_1 Y + c_2 Y^2] \cdot GCVL$$

where

STH = 0.5 ft.
CTOP = 4.0 in. for all species
BTOP = 6.0 in. for softwoods
8.0 in. for hardwoods
b_0 = 0.9604
b_1 = -0.1660
b_2 = -0.7868
c_0 = 5.4332
c_1 = -1.6281
c_2 = -4.4710

Species Group	a_0	a_1
1	0.691	363.676
2	0.710	355.623
3	1.226	315.832
4	2.139	301.634
5	4.167	244.906
6	1.112	350.092
7	-0.312	436.683
8	2.222	300.373
9	1.449	344.754
10	1.046	383.972
11	0.948	401.456
12	0.959	334.829
13	0.033	393.336
14	0.634	440.496
15	1.877	332.585
16	1.512	336.509

For the species composition of each group see page 32.

APPENDIX D

INVENTORY DESIGN AND SAMPLE SIZE ESTIMATION

Inventory Design

INVENT analyzes data based on two sampling designs:

(1) simple random sampling,

(2) stratified random sampling with simple random sampling within each stratum.

Sampling is assumed without replacement--that is, sample units (plots or points) are far enough apart so that a tree is sampled on only one sample unit.[1]

INVENT allows for the possibility of double sampling regression estimation of volume. The error associated with regression estimation is small relative to the error among sample units. Thus, it is ignored in the discussion given below on sample size approximation.

Foresters commonly use systematic sampling rather than simple random sampling. Generally, estimates from systematic sampling are somewhat more precise than from simple random sampling provided the systematic sample units are spread well over the tract sampled. Therefore, confidence intervals based on simple random equations provide somewhat conservative estimates for well-representative systematically collected data. For the same reason, sample size is usually overestimated.

Sample Size

Sample size is treated briefly. More detailed explanations are given in Barrett and Nutt (1975), Cochran (1977), Freese (1962), and Dilworth and Bell (1976).

---

[1] If a tree is sampled on more than one sample unit, the estimated means are still unbiased but the variance is underestimated.

Simple Random Sample

Sample size from simple random sampling is estimated by the following equation:[2]

$$n = \left[\frac{t\ CV}{E}\right]^2 \qquad \text{Equation 1}$$

where t is a t-value, CV is the coefficient of variation, and E is the allowable error in percent.

The t-value depends on the confidence level desired. The approximate t-values for the most widely used confidence levels are:

Confidence level (percent)	t-value
80	1.3
90	1.7
95	2.0
99	2.7

The coefficient of variation is a measure of the variability among volume estimates in a forest based on a particular technique of sampling.

Assume that from past experience a forester estimates that the coefficient of variation is 50 percent when he samples with a 10 B.A.F. prism. He wants to estimate the volume on a tract with an allowable error of 10 percent at the 95 percent confidence level. That is, he wants the chances to be 95 in 100 that his estimate after completing the inventory is within 10 percent of the actual volume.[3]

The sample size by Equation 1 is estimated as follows:

$$n = \left[\frac{t\ CV}{E}\right]^2 = \left[\frac{2\ (50)}{10}\right]^2 = 100 \text{ points}$$

Thus, the forester must select 100 points.

---

[2] The estimate of sample size using simple random and the subsequent estimates using stratified random sampling can be adjusted by the equation

$$n_a = \frac{n}{1 + P/100}$$

where P is the percent cruise. This additional refinement in estimating sample size is generally not necessary except on small tracts.

[3] To be within 10 percent of the actual volume implies that errors such as tree measurement errors, errors in estimating form class, and errors in volume equations are negligible.

Stratified Random Sampling

Often a forester divides the area into compartments or stands before beginning the inventory. In other words he stratifies the area.

If the forester's primary interest is in the estimates within each stratum, then he can specify the allowable error for each stratum and apply Equation 1 to estimate sample size.

If his primary interest is in the mean volume per acre or total volume over all strata, then he can estimate sample size by one of two techniques. Each technique depends on how sample units are allocated to strata. The two techniques will be illustrated with an example.

First consider proportional allocation. By proportional allocation, the forester determines sample size and allocates sample units to strata in proportion to the acreage of each stratum. The equation for sample size is

$$n = \left[\frac{t}{E}\right]^2 \sum_{i=1}^{L} W_i CV_i^2 \qquad \text{Equation 2}$$

where t is the t-value, E is the allowable error, W_i is the proportion of acreage in stratum i, CV_i is the coefficient of variation in stratum i, and L is the total number of strata.

Assume a forester has the following information on an 80-acre tract he wishes to sample with a 10-B.A.F. prism.

Stratum	Acreage	W_i	CV_i	$W_i CV_i^2$
1. small pines	36	.450	30	405.00
2. large pines	18	.225	50	562.50
3. mixed pine-hardwood	26	.325	80	2080.00
Totals	80	1.000	--	3047.50

Suppose he wants to estimate the mean volume per acre within 10 percent with 95 percent confidence. Then, by applying equation 2, he estimates the number of points required.

$$n = \left[\frac{t}{E}\right]^2 \sum_{i=1}^{L} W_i CV_i^2 = \left[\frac{2}{10}\right]^2 (3047.50) = 122 \text{ points}$$

He would allocate points to strata as follows:

Stratum	W_i	$n \cdot W_i$
1	.450	55
2	.225	27
3	.325	40
Totals	1.000	122

By the second technique of allocation, called Neyman allocation, the forester takes into account the coefficient of variation as well as the relative acreage in each stratum in assigning sample units to strata. Neyman allocation minimized the number of sample units required to achieve a specified precision. The equation for sample size is

$$n = \left[\frac{t}{E}\right]^2 \cdot \left[\sum_{i=1}^{L} W_i CV_i\right]^2 \qquad \text{Equation 3}$$

To apply this equation to the data given above we require the following computations:

Stratum	W_i	CV_i	$W_i CV_i$
1	.450	30	13.50
2	.225	50	11.25
3	.325	80	26.00
Totals	1.000	--	50.75

Assuming an allowable error of 10 percent with 95 percent confidence, the forester estimates the number of points required.

$$n = \left[\frac{t}{E}\right]^2 \left[\sum_{i=1}^{L} W_i CV_i\right]^2 = \left[\frac{2}{10}\right]^2 (50.75)^2 = 103 \text{ points}$$

The points are allocated to strata as follows:

Stratum	$W_i CV_i$	$n \cdot W_i CV_i / \sum_{i=1}^{L} W_i CV_i$
1	13.50	27
2	11.25	23
3	26.00	53
Totals	50.75	103

Proportional and Neyman allocation are two of the most common allocations. Other techniques of allocation are given in the references cited.

APPENDIX E

PROGRAM LISTING

```
C                                                                       MAIN0010
      PROGRAM INVENT                                                    MAIN0020
C                                                                       MAIN0030
C*************************************************************************MAIN0040
C                                                                       MAIN0050
C   INVENT   VER. 3    1/1/79   DAVID S. LINDEN  I.N.E.R.  U.N.H.       MAIN0060
C                                                                       MAIN0070
C                                                                       MAIN0080
C   THIS IS THE MAIN PROGRAM OF INVENT                                  MAIN0090
C   IT PROVIDES TWO WAY USER COMMUNICATION AND SUBROUTINE CONTROL       MAIN0100
C                                                                       MAIN0110
C*************************************************************************MAIN0120
      DOUBLE PRECISION IFILE,SAMMTD,REPEAT                              MAIN0130
      INTEGER LOGANS,TOPANS,CLASIZ,REGANS,TITLE(14)                     MAIN0140
      COMMON/COMONE/CLASIZ,TITLE,MULT,PROBLV,BAF,TOPANS,REGANS,ACRES    MAIN0150
     1,FRAME,SAMMTD,LOGANS,IFILE                                        MAIN0160
      DATA PROBLV/.05/                                                  MAIN0170
C OPEN OUTPUT FILE                                                      MAIN0180
      OPEN(UNIT=3,ACCESS='SEQOUT',FILE='INVENT.LPT')                    MAIN0190
C                                                                       MAIN0200
C ******************************                                        MAIN0210
C USER COMMUNICATION PORTION                                            MAIN0220
C ******************************                                        MAIN0230
C                                                                       MAIN0240
C ASK USER IF HE WANTS TO USE ALTERNATE F.C.'S                          MAIN0250
   10 WRITE(5,20)                                                       MAIN0260
   20 FORMAT('0DO YOU WANT TO READ IN ALTERNATE FORM CLASSES ',         MAIN0270
     1'FROM DISK?')                                                     MAIN0280
      READ(5,270) FRMANS                                                MAIN0290
      IF(FRMANS.EQ.'YES')  CALL FRMCLS                                  MAIN0300
      IF(FRMANS.NE.'NO'.AND.FRMANS.NE.'YES')  GOTO 10                   MAIN0310
C HAVE USER SPECIFY DBH CLASS SIZE                                      MAIN0320
      WRITE(5,30)                                                       MAIN0330
   30 FORMAT('0ENTER DIAMETER CLASS SIZE')                              MAIN0340
      READ(5,*) CLASIZ                                                  MAIN0350
C HAVE USER SPECIFY NUMBER OF STRATA                                    MAIN0360
      WRITE(5,40)                                                       MAIN0370
   40 FORMAT('0ENTER NUMBER OF STRATA')                                 MAIN0380
      READ(5,*) ISTRAT                                                  MAIN0390
C ASK USER FOR NEW VALUE OF ALPHA IF DESIRED                            MAIN0400
   50 WRITE(5,60)                                                       MAIN0410
   60 FORMAT('0INVENT USES THE 95% CONFIDENCE LEVEL AS A DEFAULT.'/     MAIN0420
     1' DO YOU WISH TO USE A DIFFERENT LEVEL?')                         MAIN0430
      READ(5,270) ALPHCH                                                MAIN0440
      IF(ALPHCH.NE.'YES'.AND.ALPHCH.NE.'NO')  GOTO 50                   MAIN0450
      IF(ALPHCH.EQ.'NO')  GOTO 90                                       MAIN0460
   70 WRITE(5,80)                                                       MAIN0470
   80 FORMAT(' ENTER CONFIDENCE LEVEL AS A DECIMAL IN THE RANGE ',      MAIN0480
     1'.65 TO .99')                                                     MAIN0490
      READ(5,*) ALPHA                                                   MAIN0500
      IF(ALPHA.GT.0.99.OR.ALPHA.LT.0.65)  GOTO 70                       MAIN0510
      PROBLV=1.0-ALPHA                                                  MAIN0520
   90 CONTINUE                                                          MAIN0530
C                                                                       MAIN0540
C-------------BEGIN PROGRAM CONTROL LOOP-----------------------        MAIN0550
C                                                                       MAIN0560
      DO 310 III=1,ISTRAT                                               MAIN0570
C                                                                       MAIN0580
C HAVE USER SPECIFY INPUT FILE                                          MAIN0590
      WRITE(5,100) III                                                  MAIN0600
  100 FORMAT('0ENTER INPUT FILE NAME FOR STRATUM # ',I3)                MAIN0610
      READ(5,110) IFILE                                                 MAIN0620
  110 FORMAT(A10)                                                       MAIN0630
C OPEN INPUT FILE                                                       MAIN0640
      OPEN(UNIT=21,ACCESS='SEQIN',FILE=IFILE)                           MAIN0650
C READ INVENTORY TITLE FROM FILE                                        MAIN0660
      READ(21,120) TITLE                                                MAIN0670
  120 FORMAT(14A5)                                                      MAIN0680
C WRITE TITLE ON TERMINAL                                               MAIN0690
      WRITE(5,130) TITLE                                                MAIN0700
  130 FORMAT('0',14A5/)                                                 MAIN0710
      SVFRAM=FRAME                                                      MAIN0720
C HAVE USER SPECIFY SAMPLING METHOD                                     MAIN0730
      IF(III.GT.1)  REPEAT=' OR SAME'                                   MAIN0740
  140 WRITE(5,150) REPEAT                                               MAIN0750
  150 FORMAT('0SPECIFY SAMPLING METHOD'/'   TYPE POINT OR PLOT',A8)     MAIN0760
      READ(5,240) FRAME                                                 MAIN0770
      IF(FRAME.EQ.'SAME'.AND.III.GT.1)     160 , 170                    MAIN0780
```

```
  160 FRAME=SVFRAM                                                      MAIN0790
      GOTO 280                                                          MAIN0800
  170 IF(FRAME.NE.'POINT'.AND.FRAME.NE.'PLOT')  GOTO 140                MAIN0810
      IF(FRAME.EQ.'POINT')  SAMMTD='B.A.F.'                             MAIN0820
      IF(FRAME.EQ.'PLOT')  SAMMTD='PLOT SIZE'                           MAIN0830
C HAVE USER SPECIFY BAF OR PLOT SIZE                                    MAIN0840
      WRITE(5,180) SAMMTD                                               MAIN0850
  180 FORMAT('0ENTER ',A9)                                              MAIN0860
      READ(5,*) BAF                                                     MAIN0870
C ASK USER IF HEIGHTS ARE IN LOGS                                       MAIN0880
  190 WRITE(5,200)                                                      MAIN0890
  200 FORMAT('0ARE HEIGHTS IN FEET OR SIXTEEN FT. LOGS?'/               MAIN0900
     1'     TYPE FEET OR LOGS')                                         MAIN0910
      READ(5,210) LOGANS                                                MAIN0920
  210 FORMAT(A4)                                                        MAIN0930
      IF(LOGANS.NE.'FEET'.AND.LOGANS.NE.'LOGS')  GOTO 190               MAIN0940
C ASK USER IF HEIGHTS ARE MERCHANTABLE OR TOTAL                         MAIN0950
  220 WRITE(5,230)                                                      MAIN0960
  230 FORMAT('0ARE HEIGHTS TOTAL OR MERCHANTABLE?'/                     MAIN0970
     1'     TYPE TOTAL, MERCH, OR MIXED')                               MAIN0980
      READ(5,240)TOPANS                                                 MAIN0990
  240 FORMAT(A5)                                                        MAIN1000
      IF(LOGANS.EQ.'FEET')  MULT=1                                      MAIN1010
      IF(LOGANS.EQ.'LOGS')  MULT=16                                     MAIN1020
      IF(TOPANS.NE.'TOTAL'.AND.TOPANS.NE.'MERCH'.AND.TOPANS.NE.'MIXED') MAIN1030
     1  GOTO 220                                                        MAIN1040
C ASK USER IF REGRESSION ROUTINE IS NEEDED                              MAIN1050
  250 WRITE(5,260)                                                      MAIN1060
  260 FORMAT('0WERE THE HEIGHTS OF ALL VOLUME TREES MEASURED?')         MAIN1070
      READ(5,270) REGANS                                                MAIN1080
  270 FORMAT(A3)                                                        MAIN1090
      IF(REGANS.NE.'YES'.AND.REGANS.NE.'NO')  GOTO 250                  MAIN1100
C ASK USER FOR ACREAGE                                                  MAIN1110
  280 WRITE(5,290)                                                      MAIN1120
  290 FORMAT('0ENTER ACREAGE OF TRACT.')                                MAIN1130
      READ(5,*) ACRES                                                   MAIN1140
C                                                                       MAIN1150
C ***************************************************************     MAIN1160
C IF NEEDED RUN THE HEIGHT REGRESSION ROUTINE                           MAIN1170
C ***************************************************************     MAIN1180
C                                                                       MAIN1190
      IF(REGANS.EQ.'NO')  CALL LINREG(IFILE,TOPANS)                     MAIN1200
C                                                                       MAIN1210
C ****************************************                              MAIN1220
C  READ IN TREE DATA AND PROCESS                                        MAIN1230
C ****************************************                              MAIN1240
  300 CALL GOTS                                                         MAIN1250
C                                                                       MAIN1260
C ***********************************                                   MAIN1270
C CALL THE OUTPUT ROUTINE                                               MAIN1280
C ***********************************                                   MAIN1290
C                                                                       MAIN1300
      CALL OUTP1                                                        MAIN1310
C                                                                       MAIN1320
C ****************************************                              MAIN1330
C ACCUMULATE TOTALS FROM EACH STRATA                                    MAIN1340
C ****************************************                              MAIN1350
C                                                                       MAIN1360
      IF(ISTRAT.GT.1)  CALL STRAT(ACRES,CLASIZ)                         MAIN1370
C                                                                       MAIN1380
  310 CONTINUE                                                          MAIN1390
C                                                                       MAIN1400
C---------------END PROGRAM CONTROL LOOP-------------------------       MAIN1410
C                                                                       MAIN1420
C ***********************************                                   MAIN1430
C CALCULATE COMBINED STRATA STATISTICS                                  MAIN1440
C ***********************************                                   MAIN1450
C                                                                       MAIN1460
      IF(ISTRAT.GT.1)  CALL STRAT2                                      MAIN1470
C                                                                       MAIN1480
C                                                                       MAIN1490
C *********************************                                   MAIN1500
C OUTPUT STRATA COMBINED TOTALS                                         MAIN1510
C *********************************                                   MAIN1520
C                                                                       MAIN1530
      IF(ISTRAT.GT.1)  CALL OUTP2                                       MAIN1540
C                                                                       MAIN1550
      END                                                               MAIN1560
```

```
C                                                                       FRMC0010
      SUBROUTINE FRMCLS                                                 FRMC0020
C                                                                       FRMC0030
C***********************************************************************FRMC0040
C                                                                       FRMC0050
C   THIS SUBPROGRAM READS IN AN ARRAY OF FORM CLASSES FROM A            FRMC0060
C   USER SPECIFIED DISK FILE.  THIS DISK FILE IS FREE FORMATTED         FRMC0070
C   USING LIST DIRECTED INPUT.  THE USER IS GIVEN THE OPTION            FRMC0080
C   TO LIST THE FORM CLASSES AFTER THEY ARE READ.                       FRMC0090
C                                                                       FRMC0100
C***********************************************************************FRMC0110
C                                                                       FRMC0120
      INTEGER FC(32),SPECIE(32)                                         FRMC0130
      DOUBLE PRECISION FCFILE                                           FRMC0140
      REAL REGCOF(33),REGINT(33),SEREG(35),RSQR(33),MEANY(35)           FRMC0150
      INTEGER MINDBH(32),NTR(35),TOTNTR(35)                             FRMC0160
      COMMON/REG/REGCOF,REGINT,SPECIE,MINDBH,SEREG,NTR,RSQR,MEANY       FRMC0170
     1,TOTNTR                                                           FRMC0180
      COMMON/FORMCL/FC                                                  FRMC0190
C HAVE USER SPECIFY FORM CLASS FILE NAME                                FRMC0200
      WRITE(5,10)                                                       FRMC0210
   10 FORMAT('0ENTER FORM CLASS FILE NAME')                             FRMC0220
C READ FORM CLASSES FROM FILE                                           FRMC0230
      READ(5,20) FCFILE                                                 FRMC0240
   20 FORMAT(A10)                                                       FRMC0250
      OPEN(FILE=FCFILE,ACCESS='SEQIN',UNIT=1)                           FRMC0260
      READ(1,30) FC                                                     FRMC0270
   30 FORMAT(8(I2,X))                                                   FRMC0280
C ASK USER IF HE WANTS TO LIST FORM CLASSES JUST READ                   FRMC0290
   40 WRITE(5,50)                                                       FRMC0300
   50 FORMAT('0DO YOU WANT A LIST OF THE FORM CLASSES JUST READ?')      FRMC0310
      READ(5,60) LSTANS                                                 FRMC0320
   60 FORMAT(A3)                                                        FRMC0330
      IF(LSTANS.NE.'YES'.AND.LSTANS.NE.'NO')     GOTO 40                FRMC0340
      IF(LSTANS.EQ.'NO')     RETURN                                     FRMC0350
      WRITE(5,70) (SPECIE(I),FC(I),I=1,32)                              FRMC0360
   70 FORMAT('0',8(/' ',4(A2,' = ',I2,5X)))                             FRMC0370
      RETURN                                                            FRMC0380
      END                                                               FRMC0390
```

```
C                                                                       LNRG0010
      SUBROUTINE LINREG(IFILE,TOPANS)                                   LNRG0020
C                                                                       LNRG0030
C***********************************************************************LNRG0040
C                                                                       LNRG0050
C   THIS SUBPROGRAM READS IN DATA FROM ALL THE SAMPLE TREES             LNRG0060
C   IT FINDS THE TREES WITH HEIGHT MEASUREMENTS                         LNRG0070
C   IT THEN FITS A REGRESSION MODEL FOR EACH SPECIE SAMPLED             LNRG0080
C                                                                       LNRG0090
C       MODEL:  HEIGHT = B0 + B1 * 1/DBH                                LNRG0100
C                                                                       LNRG0110
C***********************************************************************LNRG0120
      DOUBLE PRECISION IFILE                                            LNRG0130
      REAL SEREG(35),RSQR(33),MSE,TYPSSE(3)                             LNRG0140
      REAL VARX(33),VARY(33),COVXY(33),REGCOF(33),REGINT(33)            LNRG0150
      REAL X(33),Y(33),XSUM(33),YSUM(35),XSUMSQ(33),YSUMSQ(33)          LNRG0160
      REAL XYSUM(33),MEANX(33),MEANY(35),HEIGHT,MNYCOR(3)               LNRG0170
      INTEGER SPECIE(32),NTR(35),POINT,TREES,DBH,SPEC,MINDBH(32)        LNRG0180
      INTEGER TOTNTR(35),NUMREG(3),NTRCOR(3),TOPANS                     LNRG0190
      COMMON/REG/REGCOF,REGINT,SPECIE,MINDBH,SEREG,NTR,RSQR,MEANY       LNRG0200
     1,TOTNTR                                                           LNRG0210
C SET MINIMUM DBH'S TO 8                                                LNRG0220
      DO 10 ISPEC=1,32                                                  LNRG0230
   10   MINDBH(ISPEC)=8                                                LNRG0240
C                                                                       LNRG0250
C ZERO ALL ACCUMULATORS                                                 LNRG0260
C                                                                       LNRG0270
      DO 20 JTYPE=1,3                                                   LNRG0280
        NTRCOR(JTYPE)=0                                                 LNRG0290
        MNYCOR(JTYPE)=0                                                 LNRG0300
        NUMREG(JTYPE)=0                                                 LNRG0310
   20   TYPSSE(JTYPE)=0                                                LNRG0320
      DO 30 ISPEC=1,35                                                  LNRG0330
        NTR(ISPEC)=0;YSUM(ISPEC)=0                                      LNRG0340
        SEREG(ISPEC)=0;MEANY(ISPEC)=0                                   LNRG0350
        IF(ISPEC.GT.32)  GOTO 30                                        LNRG0360
        XSUM(ISPEC)=0;XSUMSQ(ISPEC)=0                                   LNRG0370
        YSUMSQ(ISPEC)=0;XYSUM(ISPEC)=0                                  LNRG0380
        REGCOF(ISPEC)=0;REGINT(ISPEC)=0;RSQR(ISPEC)=0                   LNRG0390
   30 CONTINUE                                                          LNRG0400
C                                                                       LNRG0410
C INPUT POINT INFORMATION                                               LNRG0420
C                                                                       LNRG0430
   40 READ(21,50,END=130) POINT,TREES                                   LNRG0440
   50 FORMAT(I2,X,I2)                                                   LNRG0450
C CHECK TO SEE IF DATA IS IN SUMMARY FORM                               LNRG0460
      IF(POINT.NE.-9)  GOTO 60                                          LNRG0470
      TREES=1000000                                                     LNRG0480
C INPUT INDIVIDUAL TREE DATA                                            LNRG0490
   60 LOOP=0                                                            LNRG0500
   70 IF(LOOP.GE.TREES)  GOTO 40                                        LNRG0510
      READ(21,80,END=40) SPEC,DBH,HEIGHT,IREP                           LNRG0520
   80 FORMAT(A2,X,I2,1X,F3.0,I2)                                        LNRG0530
      IF(IREP.EQ.0)  IREP=1                                             LNRG0540
      LOOP=LOOP+IREP                                                    LNRG0550
C CHECK TO SEE IF TREE IS A CULL                                        LNRG0560
      IF(HEIGHT.EQ.999)  GOTO 70                                        LNRG0570
C CHECK DBH                                                             LNRG0580
      IF(DBH.LT.1)  DBH=1                                               LNRG0590
      IF(DBH.GT.40)  DBH=40                                             LNRG0600
C CHECK HEIGHT                                                          LNRG0610
      IF(HEIGHT.LT.0.)  HEIGHT=0.                                       LNRG0620
      IF(TOPANS.EQ.'FEET'.AND.HEIGHT.GT.200.)  HEIGHT=200.              LNRG0630
      IF(TOPANS.EQ.'LOGS'.AND.HEIGHT.GT.7.)  HEIGHT=7.                  LNRG0640
C CHECK TO SEE IF HEIGHT OF THIS TREE WAS MEASURED                      LNRG0650
      IF(HEIGHT.EQ.0)  GOTO 70                                          LNRG0660
C DECODE SPECIE CODES                                                   LNRG0670
      DO 90 ISPEC=1,32                                                  LNRG0680
   90   IF(SPEC.EQ.SPECIE(ISPEC))  GOTO 110                            LNRG0690
C PRINT ERROR MESSAGE                                                   LNRG0700
      WRITE(5,100) SPEC,POINT                                           LNRG0710
  100 FORMAT('0***ERROR*** ILLEGAL SPECIE CODE: ',A2,' AT POINT: ',I2,  LNRG0720
     1/'0DATA FOR THIS TREE IGNORED! EXECUTION CONTINUES.')              LNRG0730
      GOTO 70                                                           LNRG0740
C DETERMINE MINIMUM MERCHANTABLE DBH                                    LNRG0750
  110 IF(DBH.LT.MINDBH(ISPEC))  MINDBH(ISPEC)=DBH                       LNRG0760
```

```
C COMPUTE ACCUMULATED SUMS FOR INDIVIDUAL SPECIE                        LNRG0770
      ITYPE=33                                                          LNRG0780
      IF(ISPEC.GE.12)  ITYPE=34                                         LNRG0790
      DO 120 IDUMMY=1,IREP                                              LNRG0800
        X(ISPEC)=1.0/DBH                                                LNRG0810
        Y(ISPEC)=HEIGHT                                                 LNRG0820
        NTR(ISPEC)=NTR(ISPEC)+1                                         LNRG0830
        NTR(ITYPE)=NTR(ITYPE)+1                                         LNRG0840
        NTR( 35  )=NTR( 35  )+1                                         LNRG0850
        XSUM(ISPEC)=XSUM(ISPEC)+X(ISPEC)                                LNRG0860
        YSUM(ISPEC)=YSUM(ISPEC)+Y(ISPEC)                                LNRG0870
        YSUM(ITYPE)=YSUM(ITYPE)+Y(ISPEC)                                LNRG0880
        YSUM( 35  )=YSUM( 35  )+Y(ISPEC)                                LNRG0890
        XSUMSQ(ISPEC)=XSUMSQ(ISPEC)+X(ISPEC)**2                         LNRG0900
        YSUMSQ(ISPEC)=YSUMSQ(ISPEC)+Y(ISPEC)**2                         LNRG0910
        XYSUM(ISPEC)=XYSUM(ISPEC)+X(ISPEC)*Y(ISPEC)                     LNRG0920
  120 CONTINUE                                                          LNRG0930
      GOTO 70                                                           LNRG0940
  130 CONTINUE                                                          LNRG0950
C                                                                       LNRG0960
C COMPUTE REGRESSION PARAMETERS FOR ALL SPECIES                         LNRG0970
C                                                                       LNRG0980
      DO 170 ISPEC=1,32                                                 LNRG0990
        JTYPE=1                                                         LNRG1000
        IF(ISPEC.GE.12)  JTYPE=2                                        LNRG1010
        IF(NTR(ISPEC).LT.1)  GOTO 170                                   LNRG1020
        MEANY(ISPEC)=YSUM(ISPEC)/NTR(ISPEC)                             LNRG1030
C CHECK TO SEE IF ENOUGH TREES EXIST FOR REGRESSION                     LNRG1040
        IF(NTR(ISPEC).GE.3)  GOTO 140                                   LNRG1050
C CALULATE CORRECTION SUMS FOR SPECIES WHERE NO REGRESSION WAS RUN      LNRG1060
        MNYCOR(JTYPE)=MNYCOR(JTYPE)+YSUM(ISPEC)                         LNRG1070
        NTRCOR(JTYPE)=NTRCOR(JTYPE)+NTR(ISPEC)                          LNRG1080
        GOTO 170                                                        LNRG1090
  140   NUMREG(JTYPE)=NUMREG(JTYPE)+1                                   LNRG1100
        MEANX(ISPEC)=XSUM(ISPEC)/NTR(ISPEC)                             LNRG1110
        VARX(ISPEC)=(XSUMSQ(ISPEC)-                                     LNRG1120
     1      (XSUM(ISPEC)**2/NTR(ISPEC)))/(NTR(ISPEC)-1)                LNRG1130
        VARY(ISPEC)=(YSUMSQ(ISPEC)-                                     LNRG1140
     1      (YSUM(ISPEC)**2/NTR(ISPEC)))/(NTR(ISPEC)-1)                LNRG1150
        COVXY(ISPEC)=(XYSUM(ISPEC)-                                     LNRG1160
     1    XSUM(ISPEC)*YSUM(ISPEC)/NTR(ISPEC))/(NTR(ISPEC)-1)           LNRG1170
C CHECK TO SEE IF VARIANCE IS ZERO                                      LNRG1180
        IF(VARX(ISPEC).GT.0.000001.AND.  VARY(ISPEC).GT.0.000001)       LNRG1190
     1  GOTO 150                                                       LNRG1200
        REGINT(ISPEC)=MEANY(ISPEC)                                      LNRG1210
        GOTO 160                                                        LNRG1220
  150   REGCOF(ISPEC)=COVXY(ISPEC)/VARX(ISPEC)                          LNRG1230
        REGINT(ISPEC)=MEANY(ISPEC)-REGCOF(ISPEC)*MEANX(ISPEC)           LNRG1240
  160   IF(VARY(ISPEC).LT.0.0000001)  GOTO 170                          LNRG1250
        SSE=YSUMSQ(ISPEC)-REGINT(ISPEC)*YSUM(ISPEC)-                    LNRG1260
     1  REGCOF(ISPEC)*XYSUM(ISPEC)                                     LNRG1270
        TYPSSE(JTYPE)=TYPSSE(JTYPE)+SSE                                 LNRG1280
        MSE=SSE/(NTR(ISPEC)-2)                                          LNRG1290
        SEREG(ISPEC)=SQRT(MSE/NTR(ISPEC))*100/MEANY(ISPEC)              LNRG1300
        RSQR(ISPEC)=100*(COVXY(ISPEC)**2)/(VARX(ISPEC)*VARY(ISPEC))     LNRG1310
  170 CONTINUE                                                          LNRG1320
C                                                                       LNRG1330
C COMPUTE STANDARD ERROR FOR SOFTWOOD,HARDWOOD, ALL SPECIES             LNRG1340
C                                                                       LNRG1350
      NTRCOR(3)=NTRCOR(1)+NTRCOR(2)                                     LNRG1360
      MNYCOR(3)=MNYCOR(1)+MNYCOR(2)                                     LNRG1370
      TYPSSE(3)=TYPSSE(1)+TYPSSE(2)                                     LNRG1380
      NUMREG(3)=NUMREG(1)+NUMREG(2)                                     LNRG1390
      DO 180 JTYPE=1,3                                                  LNRG1400
        ISPEC=JTYPE+32                                                  LNRG1410
        IF(NTR(ISPEC).LE.0)  GOTO 180                                   LNRG1420
        MEANY(ISPEC)=YSUM(ISPEC)/NTR(ISPEC)                             LNRG1430
        CORNTR=NTR(ISPEC)-NTRCOR(JTYPE)                                 LNRG1440
        IF(CORNTR.LE.0)  GOTO 180                                       LNRG1450
        CORMNY=(YSUM(ISPEC)-MNYCOR(JTYPE))/CORNTR                       LNRG1460
        MSE=TYPSSE(JTYPE)/(CORNTR-2*NUMREG(JTYPE))                      LNRG1470
        SEREG(ISPEC)=SQRT(MSE/CORNTR)*100/CORMNY                        LNRG1480
  180 CONTINUE                                                          LNRG1490
      CLOSE(UNIT=21)                                                    LNRG1500
      OPEN(UNIT=21,ACCESS='SEQIN',FILE=IFILE)                           LNRG1510
      SKIP RECORD 21                                                    LNRG1520
      RETURN                                                            LNRG1530
      END                                                               LNRG1540
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C                                                                       GUTS0010
      SUBROUTINE GUTS                                                   GUTS0020
C                                                                       GUTS0030
C***********************************************************************GUTS0040
C                                                                       GUTS0050
C   THIS SUBPROGRAM IS THE 'GUTS' OF INVENT.                            GUTS0060
C                                                                       GUTS0070
C   GUTS PERFORMS THE FOLLOWING:                                        GUTS0080
C                                                                       GUTS0090
C      1.  INPUTS PLOT AND TREE DATA                                    GUTS0100
C      2.  CALCULATES BASAL AREA, TREES PER ACRE AND ALL VOLUMES        GUTS0110
C      3.  CALCULATES VARIANCES AND STANDARD ERRORS                     GUTS0120
C                                                                       GUTS0130
C***********************************************************************GUTS0140
      DOUBLE PRECISION SAMMTD,IFILE                                     GUTS0150
      INTEGER REGANS,ISTART(2),ISTOP(2),DBH,SPEC,TOTNTR(35)             GUTS0160
      INTEGER SPECIE(32),POINT,TREES,TRECNT(40,32)                      GUTS0170
      INTEGER CLASIZ,TITLE(14),MULT,TOPANS,MINDBH(32),NTR(35)           GUTS0180
      REAL VARBRD(35),VARPUL(35),SEREG(35),RSQR(33),MEANY(35)           GUTS0190
      REAL REGINT(33),REGCOF(33),SECUB(35),SEBRD(35)                    GUTS0200
      REAL CUBPT(35),BRDPT(35),PULPT(35),CUBSQ(35),BRDSQ(35)            GUTS0210
      REAL BASPAC(40,35),BASTOT(35),TREPAC(40,35),TRETOT(35)            GUTS0220
      REAL CBVLSM(40,35),CBTOT(35),BDVLSM(40,35),BDTOT(35),HEIGHT       GUTS0230
      REAL SEPUL(35),PULSQ(35),PLVLSM(40,35),PLTOT(35)                  GUTS0240
      COMMON/COMUNE/CLASIZ,TITLE,MULT,PROBLV,BAF,TOPANS,REGANS,ACRES    GUTS0250
     1,FRAME,SAMMTD,LOGANS,IFILE                                        GUTS0260
      COMMON/REG/REGCOF,REGINT,SPECIE,MINDBH,SEREG,NTR,RSQR,MEANY       GUTS0270
     1,TOTNTR                                                           GUTS0280
      COMMON/OUT1/BASPAC,BASTOT,BDTOT,BDVLSM,CBTOT,CBVLSM,TREPAC,TRETOT GUTS0290
     1,SECUB,SEBRD,NPNTS,PLVLSM,PLTOT,SEPUL,FINPOP,VARBRD,VARPUL        GUTS0300
      DATA (SPECIE(I),I=1,32)/'WP','RP','PP','HM','BF','TA','SP','NS'   GUTS0310
     1,'SC','CE','OS','SM','RM','WA','WI','AS','YP','BC','WB'          GUTS0320
     2,'YB','SB','GB','BE','BW','RO','WO','BO','EL','GU'               GUTS0330
     3,'HI','BH','OH'/                                                  GUTS0340
      DATA ISTART(1)/1/,ISTART(2)/12/,ISTOP(1)/11/,ISTOP(2)/32/         GUTS0350
C                                                                       GUTS0360
C ZERO ALL ACCUMULATORS                                                 GUTS0370
C                                                                       GUTS0380
      DO 10 ISPEC=1,35                                                  GUTS0390
        BASTOT(ISPEC)=0;TRETOT(ISPEC)=0;CBTOT(ISPEC)=0;BDTOT(ISPEC)=0   GUTS0400
        PLTOT(ISPEC)=0;TOTNTR(ISPEC)=0                                  GUTS0410
        CUBSQ(ISPEC)=0 ; BRDSQ(ISPEC)=0 ; PULSQ(ISPEC)=0                GUTS0420
        SECUB(ISPEC)=0;SEBRD(ISPEC)=0;SEPUL(ISPEC)=0                    GUTS0430
        DO 10 DBH=CLASIZ,40,CLASIZ                                      GUTS0440
          TREPAC(DBH,ISPEC)=0;BASPAC(DBH,ISPEC)=0                       GUTS0450
          CBVLSM(DBH,ISPEC)=0;BDVLSM(DBH,ISPEC)=0                       GUTS0460
          PLVLSM(DBH,ISPEC)=0                                           GUTS0470
          IF(ISPEC.LT.33)  TRECNT(DBH,ISPEC)=0                          GUTS0480
   10 CONTINUE                                                          GUTS0490
      NPNTS=0                                                           GUTS0500
C                                                                       GUTS0510
C ****************************************                              GUTS0520
C READ IN ALL TREE DATA AND ACCUMULATE SUMS                             GUTS0530
C ****************************************                              GUTS0540
C                                                                       GUTS0550
C INPUT POINT OR PLOT INFORMATION                                       GUTS0560
C                                                                       GUTS0570
   20 READ(21,30,END=140) POINT,TREES                                   GUTS0580
   30 FORMAT(I2,I3)                                                     GUTS0590
C CHECK TO SEE IF DATA IS IN SUMMARY FORM                               GUTS0600
      IF(POINT.NE.-9)  GOTO 40                                          GUTS0610
      NPNTS=TREES                                                       GUTS0620
      TREES=1000000                                                     GUTS0630
C INPUT INDIVIDUAL TREE DATA                                            GUTS0640
   40 LOOP=0                                                            GUTS0650
   50 IF(LOOP.GE.TREES)  GOTO 120                                       GUTS0660
        READ(21,60,END=120) SPEC,DBH,PROD,HEIGHT,IREP,PCTSAW            GUTS0670
   60   FORMAT(A2,X,I2,A1,F3.0,I2,F3.2)                                 GUTS0680
        IF(IREP.EQ.0)  IREP=1                                           GUTS0690
        LOOP=LOOP+IREP                                                  GUTS0700
C DECODE SPECIE CODES                                                   GUTS0710
        DO 70 I=1,32                                                    GUTS0720
   70     IF(SPEC.EQ.SPECIE(I))  GOTO 90                                GUTS0730
C PRINT ERROR MESSAGE                                                   GUTS0740
        WRITE(5,80) SPEC,POINT                                          GUTS0750
   80 FORMAT('0***ERROR*** ILLEGAL SPECIE CODE: ',A2,' AT POINT: ',I2,  GUTS0760
     1/'0DATA FOR THIS TREE IGNORED! EXECUTION CONTINUES.')              GUTS0770
        GOTO 50                                                         GUTS0780
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C CHECK DBH TO SEE IF WITHIN LEGAL LIMITS                                       GUTS0790
   90 IF(DBH.LT.CLASIZ)   DBH=CLASIZ                                            GUTS0800
      IF(DBH.GT.40)   DBH=40                                                    GUTS0810
C TALLY TREES FOR EACH SPECIES                                                  GUTS0820
      ISPEC=I                                                                   GUTS0830
      TRECNT(DBH,ISPEC)=TRECNT(DBH,ISPEC) +IREP                                 GUTS0840
C CHECK TO SEE IF DIAMETER IS ABOVE MINIMUM LIMIT                               GUTS0850
      IF(DBH.LT.MINDBH(ISPEC).AND.REGANS.EQ.'NO')  GOTO 50                      GUTS0860
C ACCUMULATE NUMBER OF NON-CULL TREES ABOVE MIN DBH SAMPLED                     GUTS0870
      TOTNTR(ISPEC)=TOTNTR(ISPEC)+IREP                                          GUTS0880
      IF(ISPEC.LE.11)   TOTNTR(33)=TOTNTR(33)+IREP                              GUTS0890
      IF(ISPEC.GE.12)   TOTNTR(34)=TOTNTR(34)+IREP                              GUTS0900
      TOTNTR(35)=TOTNTR(35)+IREP                                                GUTS0910
C IF HEIGHT WAS NOT MEASURED GENERATE HEIGHT FROM REGRESSION                    GUTS0920
      IF(HEIGHT.EQ.0.AND.REGANS.EQ.'NO')  HEIGHT=REGINT(I)+REGCOF(I)/DBHGUTS0930
      IF(HEIGHT.EQ.0)   GOTO 50                                                 GUTS0940
C COMPUTE VOLUMES                                                               GUTS0950
C CHECK TO SEE IF TREE A CULL                                                   GUTS0960
      IF(HEIGHT.EQ.999)  GOTO 50                                                GUTS0970
      HEIGHT=HEIGHT*MULT                                                        GUTS0980
C CHECK HEIGHT TO SEE IF WITHIN LEGAL LIMITS                                    GUTS0990
      IF(HEIGHT.LT.0)   HEIGHT=0                                                GUTS1000
      IF(MULT.EQ.1.AND.HEIGHT.GT.200)   HEIGHT=200.                             GUTS1010
      IF(MULT.EQ.16.AND.HEIGHT.GT.128)  HEIGHT=128                              GUTS1020
      IF(TOPANS.EQ.'TOTAL')   CALL VOLTOT(DBH,HEIGHT,ISPEC,CUBVOL,BDVOL)       GUTS1030
      IF(TOPANS.EQ.'MERCH')   CALL VOLMER(DBH,HEIGHT,ISPEC,CUBVOL,BDVOL)       GUTS1040
      IF(TOPANS.EQ.'MIXED'.AND.ISPEC.GT.11)       CALL VOLMER(DBH,HEIGHT,GUTS1050
     1ISPEC,CUBVOL,BDVOL)                                                       GUTS1060
      IF(TOPANS.EQ.'MIXED'.AND.ISPEC.LE.11)       CALL VOLTOT(DBH,HEIGHT,GUTS1070
     1ISPEC,CUBVOL,BDVOL)                                                       GUTS1080
      PULVOL=0                                                                  GUTS1090
C CHECK TO SEE IF % SAWLOG OPTION USED                                          GUTS1100
      IF(PROD.NE.'%')   GOTO 100                                                GUTS1110
C CHECK PCTSAW TO SEE IF WITHIN LEGAL LIMITS                                    GUTS1120
      IF(PCTSAW.LT.0)   PCTSAW=0.0                                              GUTS1130
      IF(PCTSAW.GT.1.0)   PCTSAW=1.0                                            GUTS1140
      BDVOL =PCTSAW*BDVOL                                                       GUTS1150
      PULVOL=(1.-PCTSAW)*CUBVOL                                                 GUTS1160
      CUBVOL=PCTSAW*CUBVOL                                                      GUTS1170
      GOTO 110                                                                  GUTS1180
C CHECK TO SEE IF TREE IS PULPWOOD                                              GUTS1190
  100 IF(PROD.NE.'P')   GOTO 110                                                GUTS1200
      PULVOL=CUBVOL;CUBVOL=0;BDVOL=0                                            GUTS1210
  110 CBVLSM(DBH,ISPEC)=CBVLSM(DBH,ISPEC)+CUBVOL*IREP                           GUTS1220
      BDVLSM(DBH,ISPEC)=BDVLSM(DBH,ISPEC)+BDVOL*IREP                            GUTS1230
      PLVLSM(DBH,ISPEC)=PLVLSM(DBH,ISPEC)+PULVOL*IREP                           GUTS1240
C                                                                               GUTS1250
C    ACCUMULATE SUMS FOR VOLUME STANDARD ERRORS                                 GUTS1260
C                                                                               GUTS1270
C      CHECK TO SEE IF DATA IS IN SUMMARY FORM                                  GUTS1280
      IF(POINT.EQ.-9)   GOTO 50                                                 GUTS1290
C                                                                               GUTS1300
      IF(FRAME.EQ.'PLOT')   FACTOR=1.0/BAF                                      GUTS1310
      IF(FRAME.EQ.'POINT')   FACTOR=BAF/(.005454*DBH**2)                        GUTS1320
      CUBPT(ISPEC)=CUBPT(ISPEC)+CUBVOL*IREP*FACTOR                              GUTS1330
      BRDPT(ISPEC)=BRDPT(ISPEC)+BDVOL*IREP*FACTOR                               GUTS1340
      PULPT(ISPEC)=PULPT(ISPEC)+PULVOL*IREP*FACTOR                              GUTS1350
      IF(ISPEC.LE.11)   ITYPE=33                                                GUTS1360
      IF(ISPEC.GT.11)   ITYPE=34                                                GUTS1370
      CUBPT(ITYPE)=CUBPT(ITYPE)+CUBVOL*IREP*FACTOR                              GUTS1380
      BRDPT(ITYPE)=BRDPT(ITYPE)+BDVOL*IREP*FACTOR                               GUTS1390
      PULPT(ITYPE)=PULPT(ITYPE)+PULVOL*IREP*FACTOR                              GUTS1400
      CUBPT(35)=CUBPT(35)+CUBVOL*IREP*FACTOR                                    GUTS1410
      BRDPT(35)=BRDPT(35)+BDVOL*IREP*FACTOR                                     GUTS1420
      PULPT(35)=PULPT(35)+PULVOL*IREP*FACTOR                                    GUTS1430
C                                                                               GUTS1440
      GOTO 50                                                                   GUTS1450
  120 CONTINUE                                                                  GUTS1460
C IF IN SUMMARY MODE DON'T ACCUMULATE VOLUMES OR INCREMENT NPNTS                GUTS1470
      IF(POINT.EQ.-9)   GOTO 140                                                GUTS1480
C TALLY NUMBER OF POINTS SAMPLED                                                GUTS1490
      NPNTS=NPNTS+1                                                             GUTS1500
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C ACCUMULATE SUMS OF SQUARES FOR VOLUMES                                GUTS1510
      DO 130 ISPEC=1,35                                                 GUTS1520
        CUBSQ(ISPEC)=CUBSQ(ISPEC)+CUBPT(ISPEC)**2                       GUTS1530
        BRDSQ(ISPEC)=BRDSQ(ISPEC)+BRDPT(ISPEC)**2                       GUTS1540
        PULSQ(ISPEC)=PULSQ(ISPEC)+PULPT(ISPEC)**2                       GUTS1550
        CUBPT(ISPEC)=0                                                  GUTS1560
        PULPT(ISPEC)=0                                                  GUTS1570
  130   BRDPT(ISPEC)=0                                                  GUTS1580
      GOTO 20                                                           GUTS1590
  140 CONTINUE                                                          GUTS1600
C IF ONLY ONE POINT SAMPLED, SET IN SUMMARY MODE                        GUTS1610
      IF(NPNTS.EQ.1)  POINT=-9                                          GUTS1620
C                                                                       GUTS1630
C *****************************                                         GUTS1640
C DETERMINE SAMPLING METHOD                                             GUTS1650
C *****************************                                         GUTS1660
C                                                                       GUTS1670
      IF(FRAME.EQ.'PLOT')  GOTO  170                                    GUTS1680
C                                                                       GUTS1690
C ***************************************************                   GUTS1700
C       POINT SAMPLING                                                  GUTS1710
C                                                                       GUTS1720
C CALCULATE PER ACRE ESTIMATES FOR INDIVIDUAL SPECIES                   GUTS1730
C ***************************************************                   GUTS1740
C                                                                       GUTS1750
      DO 160 ISPEC=1,32                                                 GUTS1760
        DO 150 DBH=CLASIZ,40,CLASIZ                                     GUTS1770
C CHECK TO SEE IF ANY TREES TALLIED                                     GUTS1780
          IF(TRECNT(DBH,ISPEC).EQ.0)  GOTO 150                          GUTS1790
C BASAL AREA CALCULATIONS                                               GUTS1800
          BASPAC(DBH,ISPEC)=TRECNT(DBH,ISPEC)*BAF/NPNTS                 GUTS1810
          BASTOT(ISPEC)=BASTOT(ISPEC)+BASPAC(DBH,ISPEC)                 GUTS1820
C TREES PER ACRE CALCULATIONS                                           GUTS1830
          TREPAC(DBH,ISPEC)=BASPAC(DBH,ISPEC)/(.005454*DBH**2)          GUTS1840
          TRETOT(ISPEC)=TRETOT(ISPEC)+TREPAC(DBH,ISPEC)                 GUTS1850
C CUBIC VOLUME CALCULATIONS                                             GUTS1860
          CBVLSM(DBH,ISPEC)=CBVLSM(DBH,ISPEC)*BAF/                      GUTS1870
     1     (NPNTS*.005454*DBH**2)                                       GUTS1880
          CBTOT(ISPEC)=CBTOT(ISPEC)+CBVLSM(DBH,ISPEC)                   GUTS1890
C BOARD FOOT VOLUME CALCULATIONS                                        GUTS1900
          BDVLSM(DBH,ISPEC)=BDVLSM(DBH,ISPEC)*BAF/                      GUTS1910
     1     (NPNTS*.005454*DBH**2)                                       GUTS1920
        BDTOT(ISPEC)=BDTOT(ISPEC)+BDVLSM(DBH,ISPEC)                     GUTS1930
C PULPWOOD CALCULATIONS                                                 GUTS1940
          PLVLSM(DBH,ISPEC)=PLVLSM(DBH,ISPEC)*BAF/                      GUTS1950
     1    (NPNTS*.005454*DBH**2)                                        GUTS1960
          PLTOT(ISPEC)=PLTOT(ISPEC)+PLVLSM(DBH,ISPEC)                   GUTS1970
  150   CONTINUE                                                        GUTS1980
  160 CONTINUE                                                          GUTS1990
      GOTO 200                                                          GUTS2000
C                                                                       GUTS2010
C ***************************************************                   GUTS2020
C       PLOT SAMPLING                                                   GUTS2030
C                                                                       GUTS2040
C CALCULATE PER ACRE ESTIMATES FOR INDIVIDUAL SPECIES                   GUTS2050
C ***************************************************                   GUTS2060
C                                                                       GUTS2070
  170 PLTSIZ=BAF                                                        GUTS2080
      NPLOTS=NPNTS                                                      GUTS2090
      DO 190 ISPEC=1,32                                                 GUTS2100
        DO 180 DBH=CLASIZ,40,CLASIZ                                     GUTS2110
C CHECK TO SEE IF ANY TREES TALLIED                                     GUTS2120
          IF(TRECNT(DBH,ISPEC).EQ.0)  GOTO 180                          GUTS2130
C TREES PER ACRE CALCULATIONS                                           GUTS2140
          TREPAC(DBH,ISPEC)=TRECNT(DBH,ISPEC)/PLTSIZ/NPLOTS             GUTS2150
          TRETOT(ISPEC)=TRETOT(ISPEC)+TREPAC(DBH,ISPEC)                 GUTS2160
C BASAL AREA CALCULATIONS                                               GUTS2170
          BASPAC(DBH,ISPEC)=TREPAC(DBH,ISPEC)*.005454*DBH**2            GUTS2180
          BASTOT(ISPEC)=BASTOT(ISPEC)+BASPAC(DBH,ISPEC)                 GUTS2190
C CUBIC VOLUME CALCULATIONS                                             GUTS2200
          CBVLSM(DBH,ISPEC)=CBVLSM(DBH,ISPEC)/PLTSIZ/NPLOTS             GUTS2210
          CBTOT(ISPEC)=CBTOT(ISPEC)+CBVLSM(DBH,ISPEC)                   GUTS2220
C BOARD FOOT VOLUME CALCULATIONS                                        GUTS2230
          BDVLSM(DBH,ISPEC)=BDVLSM(DBH,ISPEC)/PLTSIZ/NPLOTS             GUTS2240
          BDTOT(ISPEC)=BDTOT(ISPEC)+BDVLSM(DBH,ISPEC)                   GUTS2250
C PULPWOOD CALCULATIONS                                                 GUTS2260
          PLVLSM(DBH,ISPEC)=PLVLSM(DBH,ISPEC)/PLTSIZ/NPLOTS             GUTS2270
          PLTOT(ISPEC)=PLTOT(ISPEC)+PLVLSM(DBH,ISPEC)                   GUTS2280
  180   CONTINUE                                                        GUTS2290
  190 CONTINUE                                                          GUTS2300
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C                                                                       GUTS2310
C ********************************************                          GUTS2320
C CALCULATE TOTALS FOR SOFTWOODS AND HARDWOODS                          GUTS2330
C ********************************************                          GUTS2340
C                                                                       GUTS2350
  200 DO 230 ITYPE=33,34                                                GUTS2360
        DO 220 DBH=CLASIZ,40,CLASIZ                                     GUTS2370
          DO 210 ISPEC=ISTART(ITYPE-32),ISTOP(ITYPE-32)                 GUTS2380
            BASPAC(DBH,ITYPE)=BASPAC(DBH,ITYPE)+BASPAC(DBH,ISPEC)       GUTS2390
            TREPAC(DBH,ITYPE)=TREPAC(DBH,ITYPE)+TREPAC(DBH,ISPEC)       GUTS2400
            CBVLSM(DBH,ITYPE)=CBVLSM(DBH,ITYPE)+CBVLSM(DBH,ISPEC)       GUTS2410
            BDVLSM(DBH,ITYPE)=BDVLSM(DBH,ITYPE)+BDVLSM(DBH,ISPEC)       GUTS2420
  210       PLVLSM(DBH,ITYPE)=PLVLSM(DBH,ITYPE)+PLVLSM(DBH,ISPEC)       GUTS2430
          BASTOT(ITYPE)=BASTOT(ITYPE)+BASPAC(DBH,ITYPE)                 GUTS2440
          TRETOT(ITYPE)=TRETOT(ITYPE)+TREPAC(DBH,ITYPE)                 GUTS2450
          CBTOT(ITYPE)=CBTOT(ITYPE)+CBVLSM(DBH,ITYPE)                   GUTS2460
          BDTOT(ITYPE)=BDTOT(ITYPE)+BDVLSM(DBH,ITYPE)                   GUTS2470
  220     PLTOT(ITYPE)=PLTOT(ITYPE)+PLVLSM(DBH,ITYPE)                   GUTS2480
  230 CONTINUE                                                          GUTS2490
C                                                                       GUTS2500
C *********************************                                     GUTS2510
C CALCULATE TOTALS FOR ALL SPECIES                                      GUTS2520
C *********************************                                     GUTS2530
C                                                                       GUTS2540
      DO 240 DBH=CLASIZ,40,CLASIZ                                       GUTS2550
        BASPAC(DBH,35)=BASPAC(DBH,33)+BASPAC(DBH,34)                    GUTS2560
        TREPAC(DBH,35)=TREPAC(DBH,33)+TREPAC(DBH,34)                    GUTS2570
        CBVLSM(DBH,35)=CBVLSM(DBH,33)+CBVLSM(DBH,34)                    GUTS2580
        BDVLSM(DBH,35)=BDVLSM(DBH,33)+BDVLSM(DBH,34)                    GUTS2590
        PLVLSM(DBH,35)=PLVLSM(DBH,33)+PLVLSM(DBH,34)                    GUTS2600
  240 CONTINUE                                                          GUTS2610
      BASTOT(35)=BASTOT(33)+BASTOT(34)                                  GUTS2620
      TRETOT(35)=TRETOT(33)+TRETOT(34)                                  GUTS2630
      CBTOT(35)=CBTOT(33)+CBTOT(34)                                     GUTS2640
      BDTOT(35)=BDTOT(33)+BDTOT(34)                                     GUTS2650
      PLTOT(35)=PLTOT(33)+PLTOT(34)                                     GUTS2660
C                                                                       GUTS2670
C ***************************                                           GUTS2680
C CALCULATE STANDARD ERRORS                                             GUTS2690
C ***************************                                           GUTS2700
C                                                                       GUTS2710
      FINPOP=1.0                                                        GUTS2720
      IF(FRAME.EQ.'PLOT')  FINPOP=((ACRES/BAF)-NPNTS)/(ACRES/BAF)       GUTS2730
      IF(FINPOP.LT.0.0)  FINPOP=0.0                                     GUTS2740
C CHECK TO SEE IF DATA IS IN SUMMARY FORM                               GUTS2750
      IF(POINT.EQ.-9)  GOTO 270                                         GUTS2760
      DO 260 ISPEC=1,35                                                 GUTS2770
        IF(TRETOT(ISPEC).EQ.0)  GOTO 260                                GUTS2780
        IF(FRAME.EQ.'PLOT')  GOTO 250                                   GUTS2790
        PCTCRZ=100*NPNTS*BASTOT(ISPEC)/TRETOT(ISPEC)/ACRES/BAF          GUTS2800
        IF(PCTCRZ.GT.100.0)  PCTCRZ=100.0                               GUTS2810
        FINPOP=(100-PCTCRZ)/100                                         GUTS2820
  250   VARCUB=(CUBSQ(ISPEC)-NPNTS*(CBTOT(ISPEC)**2))/(NPNTS-1)         GUTS2830
        VARBRD(ISPEC)=(BRDSQ(ISPEC)-NPNTS*(BDTOT(ISPEC)**2))/(NPNTS-1)  GUTS2840
        VARPUL(ISPEC)=(PULSQ(ISPEC)-NPNTS*(PLTOT(ISPEC)**2))/(NPNTS-1)  GUTS2850
        SECUB(ISPEC)=SQRT((VARCUB/NPNTS)*FINPOP)                        GUTS2860
        SEBRD(ISPEC)=SQRT((VARBRD(ISPEC)/NPNTS)*FINPOP)                 GUTS2870
  260   SEPUL(ISPEC)=SQRT((VARPUL(ISPEC)/NPNTS)*FINPOP)                 GUTS2880
C CHECK TO SEE IF REGRESSION ROUTINE USED                               GUTS2890
  270 IF(REGANS.EQ.'YES')  RETURN                                       GUTS2900
      DO 280 ISPEC=1,35                                                 GUTS2910
        IF(TOTNTR(ISPEC).EQ.0)  GOTO 280                                GUTS2920
        REGWGT=FLOAT(TOTNTR(ISPEC)-NTR(ISPEC))/FLOAT(TOTNTR(ISPEC))     GUTS2930
        SECUB(ISPEC)=SQRT(SECUB(ISPEC)**2 +                             GUTS2940
     1      REGWGT*(SEREG(ISPEC)*CBTOT(ISPEC)/100.)**2)                 GUTS2950
        SEBRD(ISPEC)=SQRT(SEBRD(ISPEC)**2 +                             GUTS2960
     1      REGWGT*(SEREG(ISPEC)*BDTOT(ISPEC)/100.)**2)                 GUTS2970
        SEPUL(ISPEC)=SQRT(SEPUL(ISPEC)**2 +                             GUTS2980
     1      REGWGT*(SEREG(ISPEC)*PLTOT(ISPEC)/100.)**2)                 GUTS2990
  280 CONTINUE                                                          GUTS3000
      RETURN                                                            GUTS3010
      END                                                               GUTS3020
```

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C                                                                       VLMR0010
      SUBROUTINE VOLMER(DBH,HEIGHT,ISPEC,CUBVOL,BDVOL)                  VLMR0020
C                                                                       VLMR0030
C***********************************************************************VLMR0040
C                                                                       VLMR0050
C  THIS SUBPROGRAM COMPUTES THE MERCHANTABLE CUBIC AND BOARD FOOT       VLMR0060
C  VOLUMES OF INDIVIDUAL TREES.  THE INPUT PARAMETERS ARE DBH,          VLMR0070
C  MERCHANTABLE HEIGHT, AND SPECIES.                                    VLMR0080
C                                                                       VLMR0090
C  THE CUBIC FOOT EQUATIONS ARE FROM BARNARD, JOSEPH E. ET AL. 1973.    VLMR0100
C  FOREST SURVEY CUBIC-FOOT VOLUME EQUATIONS. USDA FOREST SERV.         VLMR0110
C  NE. FOREST EXP. STA. RESEARCH NOTE NE-66.                            VLMR0120
C                                                                       VLMR0130
C  THE BOARD FOOT EQUATIONS ARE FROM WIANT, H.V. AND CASTENADA, F. 1977 VLMR0140
C  MESAVAGE AND GIRARD'S VOLUME TABLES FORMULATED.  RESOURCE INVENTORY  VLMR0150
C  NOTES, USDI, BLM, DENVER, COLO.                                      VLMR0160
C                                                                       VLMR0170
C***********************************************************************VLMR0180
C                                                                       VLMR0190
      REAL HEIGHT,CUBINT(17),CUBSLP(17),BDHT                            VLMR0200
      INTEGER DBH,GRP(32),D,FC(32)                                      VLMR0210
      COMMON/FORMCL/FC                                                  VLMR0220
C                                                                       VLMR0230
C DEFINE FORM CLASS FOR THE SPECIES                                     VLMR0240
C                                                                       VLMR0250
      DATA (FC(I),I=1,32)/3*76,70,7*76,21*74/                           VLMR0260
C                                                                       VLMR0270
C DEFINE VOLUME EQUATION GROUPING FOR THE SPECIES                       VLMR0280
C                                                                       VLMR0290
      DATA (GRP(I),I=1,32)/1,1,5,4,3,5,2,5,5,6,1,7,8,9,17,9,8,10        VLMR0300
     1,4*11,12,13,14,15,14,15,14,16,2*17/                               VLMR0310
C                                                                       VLMR0320
C DEFINE THE INTERCEPTS FOR THE CUBIC VOLUME EQUATIONS                  VLMR0330
C                                                                       VLMR0340
      DATA (CUBINT(I),I=1,17)/3.5142,2.1998,1.4793,2.4784,-.0496,1.5817 VLMR0350
     1,1.6823,1.1763,1.0067,1.1809,1.1339,1.2851,.8976,1.2027,1.0009    VLMR0360
     2,1.4438,.8591/                                                    VLMR0370
C                                                                       VLMR0380
C DEFINE THE SLOPES FOR THE CUBIC VOLUME EQUATIONS                      VLMR0390
C                                                                       VLMR0400
      DATA (CUBSLP(I),I=1,17)/236,257,272,242,303,259,310,310,293,292   VLMR0410
     1,281,326,349,301,300,316,309/                                     VLMR0420
C                                                                       VLMR0430
C FUNCTION TO COMPUTE BOARD FOOT VOLUMES FOR G.F.C. 78                  VLMR0440
C                                                                       VLMR0450
      WIANT(DBH,BDHT)=(-13.35212+9.58615*BDHT+1.52968*BDHT**2)+         VLMR0460
     1    (1.79620-2.59995*BDHT-.27465*BDHT**2)*DBH+                    VLMR0470
     2    (.04482+.45997*BDHT-.00961*BDHT**2)*DBH**2                    VLMR0480
C                                                                       VLMR0490
C DETERMINE BOARD FOOT HEIGHT TO THE HALF-LOG                           VLMR0500
C                                                                       VLMR0510
      BDHT=HEIGHT/16.0                                                  VLMR0520
      CBHT=HEIGHT                                                       VLMR0530
C                                                                       VLMR0540
C CALCULATE CUBIC AND BOARD FOOT VOLUME                                 VLMR0550
C                                                                       VLMR0560
      CUBVOL=CUBINT(GRP(ISPEC))+.00001*CUBSLP(GRP(ISPEC))*CBHT*DBH**2   VLMR0570
      BDVOL=WIANT(DBH,BDHT)*(((FC(ISPEC)-78)*.03)+1)                    VLMR0580
      IF(BDHT.LT.0.5)   BDVOL=0                                         VLMR0590
      IF(CUBVOL.LT.0)   CUBVOL=0                                        VLMR0600
      IF(BDVOL.LT.0)   BDVOL=0                                          VLMR0610
      RETURN                                                            VLMR0620
      END                                                               VLMR0630
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C                                                                       VLTT0010
      SUBROUTINE VOLTOT(DBH,HEIGHT,ISPEC,CUBVOL,BDVOL)                  VLTT0020
C                                                                       VLTT0030
C***********************************************************************VLTT0040
C                                                                       VLTT0050
C  THIS SUBPROGRAM COMPUTES THE MERCHANTABLE CUBIC AND BOARD FOOT       VLTT0060
C  VOLUMES OF INDIVIDUAL TREES.  THE INPUT PARAMETERS ARE DBH,          VLTT0070
C  TOTAL HEIGHT, AND SPECIES.                                           VLTT0080
C                                                                       VLTT0090
C  ALL OF THE EQUATIONS USED ARE FROM HONER, T.G. 1967. STANDARD VOLUME VLTT0100
C  TABLES AND MERCHANTABLE CONVERSION FACTORS FOR THE COMMERCIAL TREE   VLTT0110
C  SPECIES OF CENTRAL AND EASTERN CANADA. FMR-X-5, FMI, OTTAWA, CANADA  VLTT0120
C                                                                       VLTT0130
C***********************************************************************VLTT0140
C                                                                       VLTT0150
      INTEGER GRP(32),DBH                                               VLTT0160
      REAL CUBINT(16),CUBSLP(16),ASDRCF(3),ASDRBF(3),BRDTOP(2),CUBTOP(2)VLTT0170
C                                                                       VLTT0180
C DEFINE VOLUME EQUATION GROUPING FOR THE TREE SPECIES                  VLTT0190
C                                                                       VLTT0200
      DATA (GRP(I),I=1,32)/1,2,2,6,4,2,3,3,2,5,2,10,10,16,15,7,10,13    VLTT0210
     1,8,9,8,8,12,11,3*16,14,16,16,15,15/                               VLTT0220
C                                                                       VLTT0230
C DEFINE THE INTERCEPTS FOR THE TOTAL CUBIC FT VOL EQUATION             VLTT0240
C                                                                       VLTT0250
      DATA (CUBINT(I),I=1,16)/-.691,-.710,1.226,2.139,4.167,1.112,-.312 VLTT0260
     1,2.222,1.449,1.046,-.948,-.959,-.033,-.634,1.877,1.512/           VLTT0270
C                                                                       VLTT0280
C DEFINE THE SLOPES FOR THE TOTAL CUBIC FT VOL EQUATION                 VLTT0290
C                                                                       VLTT0300
      DATA (CUBSLP(I),I=1,16)/363.676,355.623,315.832,301.634,244.906   VLTT0310
     1,350.092,436.683,300.373,344.754,383.972,401.456,334.829          VLTT0320
     2,393.366,440.496,332.585,336.509/                                 VLTT0330
C                                                                       VLTT0340
C DEFINE STUMP HEIGHT AND MERCH TOPS                                    VLTT0350
C                                                                       VLTT0360
      DATA STUMP/0.5/                                                   VLTT0370
      DATA (CUBTOP(I),I=1,2)/4.0,4.0/                                   VLTT0380
      DATA (BRDTOP(I),I=1,2)/6.0,8.0/                                   VLTT0390
C                                                                       VLTT0400
C DEFINE ADJUSTED SQRD DIA RATIO CUBIC FT VOL CONVERSION COEFFICIENTS   VLTT0410
C                                                                       VLTT0420
      DATA (ASDRCF(I),I=1,3)/.9604,-.1660,-.7868/                       VLTT0430
C                                                                       VLTT0440
C DEFINE ADJUSTED SQRD DIA RATIO BOARD FT VOL CONVERSION COEFFICIENTS   VLTT0450
C                                                                       VLTT0460
      DATA (ASDRBF(I),I=1,3)/5.4332,-1.6281,-4.4710/                    VLTT0470
C                                                                       VLTT0480
C DETERMINE SW OR HW TYPE                                               VLTT0490
C                                                                       VLTT0500
      IF(ISPEC.LE.11)   ITYPE=1                                         VLTT0510
      IF(ISPEC.GE.12)   ITYPE=2                                         VLTT0520
C                                                                       VLTT0530
C COMPUTE TOTAL CUBIC FOOT VOLUME                                       VLTT0540
C                                                                       VLTT0550
      TCBVOL=DBH**2/(CUBINT(GRP(ISPEC))+CUBSLP(GRP(ISPEC))/HEIGHT)      VLTT0560
C                                                                       VLTT0570
C COMPUTE MERCH CUBIC AND BOARD FT VOLUMES                              VLTT0580
C                                                                       VLTT0590
      XCUB=((CUBTOP(ITYPE)/DBH)**2)*(1.0+STUMP/HEIGHT)                  VLTT0600
      XBRD=((BRDTOP(ITYPE)/DBH)**2)*(1.0+STUMP/HEIGHT)                  VLTT0610
      CUBVOL=TCBVOL*(ASDRCF(1)+ASDRCF(2)*XCUB+ASDRCF(3)*XCUB**2)        VLTT0620
      BDVOL =TCBVOL*(ASDRBF(1)+ASDRBF(2)*XBRD+ASDRBF(3)*XBRD**2)        VLTT0630
      IF(CUBVOL.LT.0)   CUBVOL=0                                        VLTT0640
      IF(BDVOL.LT.0)   BDVOL=0                                          VLTT0650
      RETURN                                                            VLTT0660
      END                                                               VLTT0670
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C                                                                               STRT0010
      SUBROUTINE STRAT(ACRES,CLASIZ)                                            STRT0020
C                                                                               STRT0030
C*********************************************************************          STRT0040
C                                                                               STRT0050
C   THIS SUBPROGRAM CALCULATES COMBINED STRATA STATISTICS                       STRT0060
C                                                                               STRT0070
C*********************************************************************          STRT0080
C                                                                               STRT0090
      INTEGER CLASIZ                                                            STRT0100
      REAL STSECB(35),STSEBD(35),EFDFCB(35),EFDFBD(35)                          STRT0110
      REAL STVMCB(35),STVMBD(35),DFCB2(35),DFBD2(35)                            STRT0120
      REAL STVMPL(35),DFPL2(35),PLTST(35),STSEPL(35),EFDFPL(35)                 STRT0130
      REAL PLVLST(40,35)                                                        STRT0140
      REAL CBTST(35),BDTST(35),CBVLST(40,35),BDVLST(40,35)                      STRT0150
      COMMON/OUT1/BASPAC(40,35),BASTOT(35),BDTOT(35),BDVLSM(40,35),             STRT0160
     1CBTOT(35),CBVLSM(40,35),TREPAC(40,35),TRETOT(35)                          STRT0170
     2,SECUB(35),SEBRD(35),NPNTS,PLVLSM(40,35),PLTOT(35),SEPUL(35)              STRT0180
     3,FINPOP,VARBRD(35),VARPUL(35)                                             STRT0190
      COMMON/STOUT/CBTST,BDTST,CBVLST,BDVLST,STSECB,STSEBD,EFDFCB               STRT0200
     1,EFDFBD,TACRES,PLTST,PLVLST,STSEPL,EFDFPL                                 STRT0210
C ZERO ACCUMULATORS AND OTHER VARIABLES                                         STRT0220
      DATA ((CBVLST(J,I),BDVLST(J,I),PLVLST(J,I) , J=1,40,1)                    STRT0230
     1,CBTST(I),BDTST(I),PLTST(I),STVMCB(I),STVMBD(I),STVMPL(I)                 STRT0240
     2,DFCB2(I),DFBD2(I),DFPL2(I),EFDFCB(I),EFDFBD(I),EFDFPL(I)                 STRT0250
     3,STSECB(I),STSEBD(I),STSEPL(I) , I=1,35) / 4725*0.0 /                     STRT0260
C                                                                               STRT0270
      TACRES=TACRES+ACRES                                                       STRT0280
C                                                                               STRT0290
C ACCUMULATE SUMS FOR VOLUMES                                                   STRT0300
C                                                                               STRT0310
      DO 20 ISPEC=1,35                                                          STRT0320
        DO 10 DBH=CLASIZ,40,CLASIZ                                              STRT0330
          CBVLST(DBH,ISPEC)=CBVLST(DBH,ISPEC)+CBVLSM(DBH,ISPEC)*ACRES           STRT0340
          BDVLST(DBH,ISPEC)=BDVLST(DBH,ISPEC)+BDVLSM(DBH,ISPEC)*ACRES           STRT0350
   10     PLVLST(DBH,ISPEC)=PLVLST(DBH,ISPEC)+PLVLSM(DBH,ISPEC)*ACRES           STRT0360
        CBTST(ISPEC)=CBTST(ISPEC)+CBTOT(ISPEC)*ACRES                            STRT0370
        BDTST(ISPEC)=BDTST(ISPEC)+BDTOT(ISPEC)*ACRES                            STRT0380
        PLTST(ISPEC)=PLTST(ISPEC)+PLTOT(ISPEC)*ACRES                            STRT0390
C                                                                               STRT0400
C ACCUMULATE SUMS FOR VARIANCE AND D.F.                                         STRT0410
C                                                                               STRT0420
        IF(NPNTS.LT.2)  GOTO 20                                                 STRT0430
        STVMCB(ISPEC)=STVMCB(ISPEC)+(ACRES**2)*(SECUB(ISPEC)**2)                STRT0440
        STVMBD(ISPEC)=STVMBD(ISPEC)+(ACRES**2)*(SEBRD(ISPEC)**2)                STRT0450
        STVMPL(ISPEC)=STVMPL(ISPEC)+(ACRES**2)*(SEPUL(ISPEC)**2)                STRT0460
        DFCB2(ISPEC)=DFCB2(ISPEC)+ACRES**4*SECUB(ISPEC)**4/(NPNTS-1)            STRT0470
        DFBD2(ISPEC)=DFBD2(ISPEC)+ACRES**4*SEBRD(ISPEC)**4/(NPNTS-1)            STRT0480
        DFPL2(ISPEC)=DFPL2(ISPEC)+ACRES**4*SEPUL(ISPEC)**4/(NPNTS-1)            STRT0490
   20 CONTINUE                                                                  STRT0500
      RETURN                                                                    STRT0510
C                                                                               STRT0520
C************************************************                               STRT0530
C CALCULATE STANDARD ERRORS AND EFFECTIVE D.F.                                  STRT0540
C  BASED ON PREVIOUSLY ACCUMULATED SUMS                                         STRT0550
C************************************************                               STRT0560
C                                                                               STRT0570
      ENTRY STRAT2                                                              STRT0580
      DO 50 ISPEC=1,35                                                          STRT0590
        IF(PLTST(ISPEC).EQ.0)  GOTO 30                                          STRT0600
        STSEPL(ISPEC)=SQRT(STVMPL(ISPEC)/TACRES**2)                             STRT0610
        IF(DFPL2(ISPEC).EQ.0)  GOTO 30                                          STRT0620
        EFDFPL(ISPEC)=STVMPL(ISPEC)**2/DFPL2(ISPEC)                             STRT0630
   30   IF(CBTST(ISPEC).EQ.0)  GOTO 50                                          STRT0640
        STSECB(ISPEC)=SQRT(STVMCB(ISPEC)/TACRES**2)                             STRT0650
        STSEBD(ISPEC)=SQRT(STVMBD(ISPEC)/TACRES**2)                             STRT0660
        IF(DFCB2(ISPEC).EQ.0)  GOTO 40                                          STRT0670
        EFDFCB(ISPEC)=STVMCB(ISPEC)**2/DFCB2(ISPEC)                             STRT0680
   40   IF(DFBD2(ISPEC).EQ.0)  GOTO 50                                          STRT0690
        EFDFBD(ISPEC)=STVMBD(ISPEC)**2/DFBD2(ISPEC)                             STRT0700
   50 CONTINUE                                                                  STRT0710
      RETURN                                                                    STRT0720
      END                                                                       STRT0730
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C                                                                       OTP10010
      SUBROUTINE OUTP1                                                  OTP10020
C                                                                       OTP10030
C***********************************************************************OTP10040
C                                                                       OTP10050
C   THIS SUBPROGRAM PRODUCES ALL OF INVENTS TABLES AND SUMMARIES        OTP10060
C                                                                       OTP10070
C   THE SUBPROGRAM HAS TWO ENTRY POINTS:  OUTP1   AND   OUTP2           OTP10080
C                                                                       OTP10090
C      OUTP1 PRODUCES ALL OF THE INDIVIDUAL STRATA OUTPUT               OTP10100
C      OUTP2 PRODUCES THE STRATIFIED TOTAL OUTPUT                       OTP10110
C                                                                       OTP10120
C***********************************************************************OTP10130
      INTEGER TOTACB,TOTABD,TOTAPL,IDATE(2),TOTNTR(35),TOTPTS           OTP10140
      INTEGER DBH,TOPANS,MULT,REGANS,FC(32)                             OTP10150
      INTEGER SPETIT(35,3),TITLE(14),CLASIZ,SPECIE(32)                  OTP10160
      INTEGER MINDBH(32),NTR(35)                                        OTP10170
      REAL VARBRD(35),VARPUL(35),REGCOF(33),REGINT(33),SEREG(35)        OTP10180
      REAL RSQR(33),MEANY(35)                                           OTP10190
      REAL TREPAC(40,35),TRETOT(35),CBTOT(35),BDTOT(35),MSD             OTP10200
      REAL SECUB(35),SEBRD(35),SEPUL(35),PLVLSM(40,35),PLTOT(35)        OTP10210
      REAL CBVLSM(40,35),BDVLSM(40,35),BASPAC(40,35),BASTOT(35)         OTP10220
      DOUBLE PRECISION IFILE,SAMNTD                                     OTP10230
      COMMON/REG/REGCOF,REGINT,SPECIE,MINDBH,SEREG,NTR,RSQR,MEANY       OTP10240
     1,TOTNTR                                                           OTP10250
      COMMON/FORMCL/FC                                                  OTP10260
      COMMON/STOUT/CBTST(35),BDTST(35),CBVLST(40,35),BDVLST(40,35)      OTP10270
     1,STSECB(35),STSEBD(35),EFDFCB(35),EFDFBD(35),TACRES               OTP10280
     2,PLTST(35),PLVLST(40,35),STSEPL(35),EFDFPL(35)                    OTP10290
      COMMON/COMUNE/CLASIZ,TITLE,MULT,PROBLV,BAF,TOPANS,REGANS,ACRES    OTP10300
     1,FRAME,SAMNTD,LOGANS,IFILE                                        OTP10310
      COMMON/OUT1/BASPAC,BASTOT,BDTOT,BDVLSM,CBTOT,CBVLSM,TREPAC,TRETOT OTP10320
     1,SECUB,SEBRD,NPNTS,PLVLSM,PLTOT,SEPUL,FINPOP,VARBRD,VARPUL        OTP10330
      DATA ((SPETIT(I,J),J=1,3),I=1,35)/'WHITE PINE     RED PINE      ',OTP10340
     1'PITCH PINE      HEMLOCK         BALSAM FIR      ',               OTP10350
     2'TAMARACK        ',                                              OTP10360
     3'RD-BL-WH SPRUCENORWAY SPRUCE  SCOTCH PINE     CEDAR           ',OTP10370
     4'OTHER SOFTWOODSSUGAR MAPLE    RED MAPLE       WHITE ASH       ',OTP10380
     5'WILLOW          ASPEN           YELLOW POPLAR   ',              OTP10390
     6'BLACK CHERRY    WHITE BIRCH     YELLOW BIRCH    SWEET BIRCH     ',OTP10400
     7'GREY BIRCH      BEECH           BASSWOOD        ',              OTP10410
     8'RED OAK         WHITE OAK       BLACK OAK       ',              OTP10420
     9'ELM             GUM             HICKORY         HOPHORNBEAM     ',OTP10430
     1'OTHER HARDWOODSALL SOFTWOODS    ',                              OTP10440
     2'ALL HARDWOODS   ALL SPECIES     '/                              OTP10450
C ACCUMULATE NUMBER OF STRATA SAMPLED                                   OTP10460
      ISTRA=ISTRA+1                                                     OTP10470
C ACCUMULATE TOTAL NUMBER OF POINTS SAMPLED IN ALL STRATA               OTP10480
      TOTPTS=TOTPTS+NPNTS                                               OTP10490
C                                                                       OTP10500
C CALCULATE T-VALUE FOR THIS STRATA                                     OTP10510
C                                                                       OTP10520
      TVAL=0                                                            OTP10530
      DF=NPNTS-1                                                        OTP10540
      IF(DF.GE.1)   CALL MDSTI(PROBLV,DF,TVAL)                          OTP10550
      IPAGE=IPAGE+1                                                     OTP10560
C                                                                       OTP10570
C*********************************                                      OTP10580
C PRINT HEADING ON OUTPUT FILE                                          OTP10590
C*********************************                                      OTP10600
C                                                                       OTP10610
      CALL DATE(IDATE)                                                  OTP10620
      REGUSE='ALL'                                                      OTP10630
      IF(REGANS.EQ.'NO')  REGUSE='SOME'                                 OTP10640
      WRITE(3,100) TITLE,IPAGE                                          OTP10650
      OFRAME=FRAME                                                      OTP10660
      IF(FRAME.EQ.'PLOT')  OFRAME=' PLOT'                               OTP10670
      ALPHA=1.0-PROBLV                                                  OTP10680
      WRITE(3,10) IDATE,SAMNTD,BAF,OFRAME,NPNTS,CLASIZ,TOPANS,LOGANS,   OTP10690
     1REGUSE,ISTRA,IFILE,ACRES,ALPHA                                    OTP10700
   10 FORMAT(//' INVENT VER. 3    11/1/78    I.N.E.R.    U.N.H.'/      OTP10710
     1/'0DATE OF RUN: ',2A5//'0',A9,' =',F6.2,28X,'NUMBER OF ',A5,'S ', OTP10720
     2'SAMPLED =',I4/'0DIAMETER CLASS SIZE =',I3,21X                    OTP10730
     3,'HEIGHTS MEASURED BY ',A5,' HEIGHT IN ',A4/                      OTP10740
     4'0HEIGHTS OF ',A4,' VOLUME TREES MEASURED',8X,'STRATUM #',I3/     OTP10750
     5'0INPUT FILE NAME: ',A10,18X,'ACREAGE OF TRACT =',F7.1/           OTP10760
     6'0CONFIDENCE LEVEL = ',F3.2)                                      OTP10770
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C*****************************************************                  OTP10780
C PRINT REGRESSION ANALYSIS SUMMARY                                     OTP10790
C*****************************************************                  OTP10800
C                                                                       OTP10810
      IF(REGANS.EQ.'YES')  GOTO 90                                      OTP10820
      IPAGE=IPAGE+1                                                     OTP10830
      WRITE(3,100) TITLE,IPAGE                                          OTP10840
      WRITE(3,20)                                                       OTP10850
   20 FORMAT('0',99('*')/' *',97X,'*'/' *',28X,'ANALYSIS OF THE HEIGHT',OTP10860
     1' - DBH RELATIONSHIP',28X,'*'/' *',97X,'*'/' *',35X,'MODEL:  HEI',OTP10870
     2'GHT = B0 + B1/DBH',34X,'*'/' *',97X,'*'/' ',99('*')/'0',99('-')  OTP10880
     3/' ',15X,':',5X,'B0',4X,':',5X,'B1',4X,':',5X,'R',5X,': STANDAR',  OTP10890
     4'D  :  AVERAGE  :  VOLUME  :  HEIGHT'/'     SPECIES    : INTERC',OTP10900
     5'EPT :   SLOPE   :  SQUARED  :  ERROR %  :   HEIGHT  :   TREES  ',OTP10910
     6' :   TREES'/' ',99('-')/' ')                                     OTP10920
      IFLAG=0                                                           OTP10930
      DO 50 ISPEC=1,32                                                  OTP10940
         IF(TOTNTR(ISPEC).EQ.0)  GOTO 50                                OTP10950
         IF(NTR(ISPEC).LT.3.AND.NTR(ISPEC).LT.TOTNTR(ISPEC))  IFLAG=1   OTP10960
         IF(NTR(ISPEC).GE.3)  WRITE(3,30)  (SPETIT(ISPEC,J),J=1,3)      OTP10970
     1      ,REGINT(ISPEC),REGCOF(ISPEC),RSQR(ISPEC),SEREG(ISPEC) ,     OTP10980
     2      MEANY(ISPEC),TOTNTR(ISPEC),NTR(ISPEC)                       OTP10990
   30    FORMAT(' ',3(A5),2(':',F9.3,2X),3(':',F8.1,3X),2(':',I8,3X))   OTP11000
         IF(NTR(ISPEC).LT.3.AND.NTR(ISPEC).EQ.TOTNTR(ISPEC))            OTP11010
     1     WRITE(3,60)  (SPETIT(ISPEC,J),J=1,3),SEREG(ISPEC),           OTP11020
     2     MEANY(ISPEC) ,TOTNTR(ISPEC),NTR(ISPEC)                       OTP11030
         IF(NTR(ISPEC).LT.3.AND.NTR(ISPEC).LT.TOTNTR(ISPEC))            OTP11040
     1     WRITE(3,40)  (SPETIT(ISPEC,J),J=1,3),SEREG(ISPEC),           OTP11050
     2     MEANY(ISPEC),TOTNTR(ISPEC),NTR(ISPEC)                        OTP11060
   40    FORMAT(' ',3A5,':',10X,'*** WARNING ***',10X,                  OTP11070
     1    2(':',F8.1,3X),2(':',I8,3X))                                  OTP11080
   50 CONTINUE                                                          OTP11090
      WRITE(3,250)                                                      OTP11100
      DO 70 ISPEC=33,35                                                 OTP11110
         WRITE(3,60)  (SPETIT(ISPEC,J),J=1,3),SEREG(ISPEC),MEANY(ISPEC) OTP11120
     1     ,TOTNTR(ISPEC),NTR(ISPEC)                                    OTP11130
   60    FORMAT(' ',3A5,':',35X,2(':',F8.1,3X),2(':',I8,3X))            OTP11140
   70    IF(ISPEC.EQ.34.OR.ISPEC.EQ.35)  WRITE(3,250)                   OTP11150
      IF(IFLAG.EQ.1)  WRITE(3,80)                                       OTP11160
   80 FORMAT('0'/'0*** WARNING ***    INSUFFICIENT NUMBER OF HEIGHT TR',OTP11170
     1'EES MEASURED FOR THIS SPECIES!')                                 OTP11180
C                                                                       OTP11190
C ****************************************                              OTP11200
C OUTPUT STAND AND STOCK TABLES                                         OTP11210
C ****************************************                              OTP11220
C                                                                       OTP11230
   90 DO 210 ISPEC=1,35                                                 OTP11240
        IF(TRETOT(ISPEC).EQ.0.0)  GOTO 210                              OTP11250
        IPAGE=IPAGE+1                                                   OTP11260
        WRITE(3,100) TITLE,IPAGE                                        OTP11270
  100   FORMAT('1',14A5,26X,I3/'0')                                     OTP11280
C                                                                       OTP11290
C THE FOLLOWING SECTION CONTROLS THE OUTPUT OF THE SPECIES FORM CLASS   OTP11300
C PRINTED IN THE STAND TABLE HEADING.  THE FORM CLASS IS NOT PRINTED    OTP11310
C UNDER THE FOLLOWING CONDITIONS:                                       OTP11320
C         1. STAND TABLES FOR SOFTWOOD,HARDWOOD, OR ALL SPECIES         OTP11330
C            ( ISPEC >= 33 )                                            OTP11340
C         2. TREES MEASURED BY TOTAL HEIGHT ( TOPANS = "TOTAL" )        OTP11350
C         3. STAND TABLES FOR SOFTWOODS WHEN "MIXED" HEIGHTS USED       OTP11360
C            ( TOPANS = "MIXED" AND ISPEC <= 11 )                       OTP11370
C                                                                       OTP11380
        AFCTIT=' ' ; AFCNUM=' '                                         OTP11390
        IF(ISPEC.GE.33)  GOTO 120                                       OTP11400
        IF(TOPANS.EQ.'TOTAL')  GOTO 120                                 OTP11410
        IF(TOPANS.EQ.'MIXED'.AND.ISPEC.LE.11)  GOTO 120                 OTP11420
        AFCTIT='FC = '                                                  OTP11430
C ENCODE WRITES THE INTEGER VALUE OF FC INTO AFCNUM AS ASCII CHARACTERS OTP11440
        ENCODE(2,110,AFCNUM) FC(ISPEC)                                  OTP11450
  110   FORMAT(I2)                                                      OTP11460
  120   WRITE(3,130)  (SPETIT(ISPEC,J),J=1,3),AFCTIT,AFCNUM            OTP11470
  130 FORMAT('0',99('*')/' ','*',97X,'*'/                               OTP11480
     1,' *',39X,3(A5),35X,A5,A2,X,'*'/' *',97X,'*'/                     OTP11490
     2' ',99('*')/'0',99('-')/' ',10X,':  BASAL AREA  :',               OTP11500
     3'      TREES     :       SAWLOG       :       SAWLOG       :',   OTP11510
     4'      PULPWOOD'/'  DIAMETER :'6X,'PER',5X,':',6X,'PER',5X,':',   OTP11520
     5' CUBIC FOOT VOLUME : BOARD FOOT VOLUME : CUBIC FOOT VOLUME'/     OTP11530
     6' ',' CLASS',3X,':',5X,'ACRE',5X,                                 OTP11540
     7':',5X,'ACRE',5X,3(':',5X,'PER ACRE',6X)/' ',99('-')/' ')         OTP11550
```

```
      DO 150 DBH=CLASIZ,40,CLASIZ                                          OTP11560
        IF(TREPAC(DBH,ISPEC).EQ.0.0)  GOTO 150                             OTP11570
          WRITE(3,140) DBH,BASPAC(DBH,ISPEC),TREPAC(DBH,ISPEC)             OTP11580
     1       ,CBVLSM(DBH,ISPEC),BDVLSM(DBH,ISPEC),PLVLSM(DBH,ISPEC)       OTP11590
  140     FORMAT(' ',4X,I2,4X,':',F10.1,4X,':',F10.1,4X,':',F10.1,         OTP11600
     1    2(9X,':',F10.1))                                                 OTP11610
  150 CONTINUE                                                             OTP11620
      IF(PLTOT(ISPEC).EQ.0)  IERPUL=0                                      OTP11630
      IF(PLTOT(ISPEC).NE.0)IERPUL=(SEPUL(ISPEC)*TVAL*100/PLTOT(ISPEC))+    OTP11640
     1.5                                                                   OTP11650
      IF(CBTOT(ISPEC).EQ.0)  IERCUB=0                                      OTP11660
      IF(CBTOT(ISPEC).NE.0)IERCUB=(SECUB(ISPEC)*TVAL*100/CBTOT(ISPEC))+    OTP11670
     1.5                                                                   OTP11680
      IF(BDTOT(ISPEC).EQ.0)  IERBRD=0                                      OTP11690
      IF(BDTOT(ISPEC).NE.0)IERBRD=(SEBRD(ISPEC)*TVAL*100/BDTOT(ISPEC))+    OTP11700
     1.5                                                                   OTP11710
      WRITE(3,160) BASTOT(ISPEC),TRETOT(ISPEC),CBTOT(ISPEC),IERCUB,        OTP11720
     1BDTOT(ISPEC),IERBRD,PLTOT(ISPEC),IERPUL                              OTP11730
  160 FORMAT('0',99('-')/'0',3X,'TOTAL',2X,':',3X,F7.1,4X,':',3X,F7.1      OTP11740
     1,4X,':',F10.1,' +',I3,'%',2(3X,':',F10.1,' +',I3,'%')/               OTP11750
     2'+',52X,'_',2(19X,'_')/'0',99('-'))                                  OTP11760
C CALCULATE AND OUTPUT MSD AND C.V.                                        OTP11770
      MSD=SQRT(BASTOT(ISPEC)/TRETOT(ISPEC)/.005454)                        OTP11780
      IBDCV=0 ; IPLCV=0                                                    OTP11790
      IF(BDTOT(ISPEC).NE.0)  IBDCV=SQRT(VARBRD(ISPEC))*100/BDTOT(ISPEC)+   OTP11800
     1.5                                                                   OTP11810
      IF(PLTOT(ISPEC).NE.0)  IPLCV=SQRT(VARPUL(ISPEC))*100/PLTOT(ISPEC)+   OTP11820
     1.5                                                                   OTP11830
      WRITE(3,170) MSD,IBDCV                                               OTP11840
  170 FORMAT('0'/'0',5X,'MEAN STAND DIAMETER = ',F4.1                      OTP11850
     1,9X,'BOARD FOOT COEFFICIENT OF VARIATION =',I4,'%')                  OTP11860
C CALCULATE AND OUTPUT MERCHANTABLE MSD                                    OTP11870
      RBSTOT=BASTOT(ISPEC)                                                 OTP11880
      RTRTOT=TRETOT(ISPEC)                                                 OTP11890
      DO 180 DBH=CLASIZ,7,CLASIZ                                           OTP11900
        RBSTOT=RBSTOT-BASPAC(DBH,ISPEC)                                    OTP11910
  180   RTRTOT=RTRTOT-TREPAC(DBH,ISPEC)                                    OTP11920
      IF(RTRTOT.LT.0.01)  RMSD=0                                           OTP11930
      IF(RTRTOT.GE.0.01)  RMSD=SQRT(RBSTOT/RTRTOT/.005454)                 OTP11940
      WRITE(3,190) RMSD,IPLCV                                              OTP11950
  190 FORMAT('0'/'0',5X,'MERCHANTABLE M.S.D. = ',F4.1                      OTP11960
     1,9X,'PULP-WOOD  COEFFICIENT OF VARIATION =',I4,'%')                  OTP11970
C                                                                          OTP11980
C CALCULATE AND OUTPUT (ESTIMATED) % CRUISE                                OTP11990
      IF(FRAME.EQ.'PLOT')  PCTCRZ=100*(1.0-FINPOP)                         OTP12000
      IF(FRAME.EQ.'POINT')  PCTCRZ=.5454*NPNTS*MSD*MSD/ACRES/BAF           OTP12010
      WRITE(3,200) PCTCRZ                                                  OTP12020
  200 FORMAT('0'/'0',5X,'PERCENT CRUISE =',F5.1,'%')                       OTP12030
  210 CONTINUE                                                             OTP12040
C                                                                          OTP12050
C ***************************************************                      OTP12060
C CALCULATE AND OUTPUT SPECIES COMPOSITION PERCENTAGES                     OTP12070
C ***************************************************                      OTP12080
C                                                                          OTP12090
      IPAGE=IPAGE+1                                                        OTP12100
      WRITE(3,100) TITLE,IPAGE                                             OTP12110
      WRITE(3,220)                                                         OTP12120
  220 FORMAT('0',99('*')/' *',97X,'*'/                                     OTP12130
     1,' *',30X,'SPECIES COMPOSITION BY PERCENT',37X,'*'/                  OTP12140
     2' *',97X,'*'/' ',99('*')/'0',99('-')/                                OTP12150
     3' ',3(15X,':'),2(5X,'SAWLOG',6X,':'),4X,'PULPWOOD'/                  OTP12160
     4' ',3(15X,':'),3X,'CUBIC FOOT',4X,':','   BOARD FOOT'               OTP12170
     5,4X,':',3X,'CUBIC FOOT'/                                             OTP12180
     6' ',4X,'SPECIES',4X,':','  BASAL AREA   :',5X,'TREES                OTP12190
     73(':',5X,'VOLUME',6X)/' ',99('-')/' ')                               OTP12200
      IF(CBTOT(35).EQ.0)  CBTOT(35)=-999                                   OTP12210
      IF(BDTOT(35).EQ.0)  BDTOT(35)=-999                                   OTP12220
      IF(PLTOT(35).EQ.0)  PLTOT(35)=-999                                   OTP12230
      DO 240 ISPEC=1,34                                                    OTP12240
        IF(TRETOT(ISPEC).EQ.0.0)  GOTO 240                                 OTP12250
        BASCOM=BASTOT(ISPEC)*100/BASTOT(35)                                OTP12260
        TRECOM=TRETOT(ISPEC)*100/TRETOT(35)                                OTP12270
        CUBCOM=CBTOT(ISPEC)*100/CBTOT(35)                                  OTP12280
        BDCOM=BDTOT(ISPEC)*100/BDTOT(35)                                   OTP12290
        PULCOM=PLTOT(ISPEC)*100/PLTOT(35)                                  OTP12300
```

```
      WRITE(3,230) (SPETIT(ISPEC,J),J=1,3),BASCOM    ,TRECOM,          OTP12310
     1   CUBCOM,BDCOM,PULCOM                                           OTP12320
  230   FORMAT(' ',3(A5),':',2(3X,F7.2,5X,':'),2(4X,F7.2,6X,':')       OTP12330
     1  ,4X,F7.2)                                                      OTP12340
  240   IF(ISPEC.EQ.32)  WRITE(3,250)                                   OTP12350
      WRITE(3,250)                                                     OTP12360
  250 FORMAT('0',99('-')/' ')                                          OTP12370
      IF(CBTOT(35).EQ.-999)  CBTOT(35)=0                               OTP12380
      IF(BDTOT(35).EQ.-999)  BDTOT(35)=0                               OTP12390
      IF(PLTOT(35).EQ.-999)  PLTOT(35)=0                               OTP12400
C                                                                      OTP12410
C*********************************************************           OTP12420
C OUTPUT VOLUME TOTALS FOR ALL SPECIES                                 OTP12430
C*********************************************************           OTP12440
C                                                                      OTP12450
      IPAGE=IPAGE+1                                                    OTP12460
      WRITE(3,100) TITLE,IPAGE                                         OTP12470
      WRITE(3,260)                                                     OTP12480
  260 FORMAT('0',99('*')/' *',97X,'*'/                                 OTP12490
     1' *',30X,'VOLUME TOTALS FOR ALL SPECIES',38X,'*'/                OTP12500
     2' *',97X,'*'/' ',99('*')/'0',99('-')/                            OTP12510
     3' ',15X,2(':',11X,'SAWLOG',11X),':',10X,'PULPWOOD'/              OTP12520
     4'      SPECIES    :',6X,'CUBIC FOOT VOLUME',5X,':',6X,'BOARD',   OTP12530
     5' FOOT VOLUME',5X,':',6X,'CUBIC FOOT VOLUME'/                    OTP12540
     6' ',15X,2(':',10X,'PER ACRE',10X),':',10X,'PER ACRE'/            OTP12550
     7' ',99('-')/' ')                                                 OTP12560
      DO 290 ISPEC=1,35                                                OTP12570
        IF (CBTOT(ISPEC).EQ.0.AND.PLTOT(ISPEC).EQ.0.AND.ISPEC.LT.33)   OTP12580
     1      GOTO 280                                                   OTP12590
        WRITE(3,270) (SPETIT(ISPEC,J),J=1,3),CBTOT(ISPEC),BDTOT(ISPEC), OTP12600
     1   PLTOT(ISPEC)                                                  OTP12610
  270 FORMAT(' ',3(A5),3(':',F17.1,11X))                               OTP12620
  280   IF(ISPEC.EQ.32.OR.ISPEC.EQ.34.OR.ISPEC.EQ.35)  WRITE(3,250)     OTP12630
  290 CONTINUE                                                         OTP12640
C                                                                      OTP12650
C ******************************************************             OTP12660
C OUTPUT VOLUME TOTALS EXPANDED BY ACREAGE                             OTP12670
C ******************************************************             OTP12680
C                                                                      OTP12690
      IPAGE=IPAGE+1                                                    OTP12700
      WRITE(3,100) TITLE,IPAGE                                         OTP12710
      WRITE(3,300)                                                     OTP12720
  300 FORMAT('0',99('*')/' *',97X,'*'/                                 OTP12730
     1' *',30X,'VOLUME TOTALS EXPANDED BY ACREAGE',34X,'*'/            OTP12740
     2' *',97X,'*'/' ',99('*')/'0',99('-')/                            OTP12750
     3' ',15X,2(':',11X,'SAWLOG',11X),':',10X,'PULPWOOD'/              OTP12760
     4'      SPECIES    :',6X,'CUBIC FOOT VOLUME',5X,':',6X,'BOARD',   OTP12770
     5' FOOT VOLUME',5X,':',6X,'CUBIC FOOT VOLUME'/                    OTP12780
     6' ',99('-')/' ')                                                 OTP12790
      DO 330 ISPEC=1,35                                                OTP12800
        IF (CBTOT(ISPEC).EQ.0.AND.PLTOT(ISPEC).EQ.0.AND.ISPEC.LT.33)   OTP12810
     1      GOTO 320                                                   OTP12820
        TOTACB=CBTOT(ISPEC)*ACRES+.5                                   OTP12830
        TOTABD=BDTOT(ISPEC)*ACRES+.5                                   OTP12840
        TOTAPL=PLTOT(ISPEC)*ACRES+.5                                   OTP12850
        WRITE(3,310) (SPETIT(ISPEC,J),J=1,3),TOTACB,TOTABD,TOTAPL      OTP12860
  310   FORMAT(' ',3(A5),3(':',I17,11X))                               OTP12870
  320   IF(ISPEC.EQ.32.OR.ISPEC.EQ.34.OR.ISPEC.EQ.35)  WRITE(3,250)     OTP12880
  330 CONTINUE                                                         OTP12890
      RETURN                                                           OTP12900
```

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C                                                                               OTP12910
C*******************************************************************************OTP12920
C                                                                               OTP12930
C   OUTPUT TABLES FOR STRATIFIED TOTAL                                          OTP12940
C                                                                               OTP12950
C*******************************************************************************OTP12960
C                                                                               OTP12970
      ENTRY OUTP2                                                               OTP12980
      WRITE(5,340)                                                              OTP12990
  340 FORMAT('0WHAT DO YOU WANT TO TITLE THE COMBINED STRATA OUTPUT?')           OTP13000
      READ(5,350) TITLE                                                         OTP13010
  350 FORMAT(14A5)                                                              OTP13020
      IPAGE=IPAGE+1                                                             OTP13030
      WRITE(3,100) TITLE,IPAGE                                                  OTP13040
C PRINT HEADING ON OUTPUT FILE                                                  OTP13050
      OFRAME=FRAME                                                              OTP13060
      IF(FRAME.EQ.'PLOT')  OFRAME=' PLOT'                                       OTP13070
      WRITE(3,360) IDATE,CLASIZ,ISTRA,TACRES,OFRAME,TOTPTS,ALPHA                OTP13080
  360 FORMAT(//' INVENT VER. 3   11/1/78   I.N.E.R.   U.N.H.'//                 OTP13090
     1'0DATE OF RUN: ',2A5//                                                    OTP13100
     2'0DIAMETER CLASS SIZE =',I3,21X,'NUMBER OF STRATA SAMPLED ='              OTP13110
     3,I3/'0TOTAL ACREAGE SAMPLED =',F9.1,13X,'TOTAL ',A5                       OTP13120
     4,'S SAMPLED =',I5/'0CONFIDENCE LEVEL = ',F3.2)                            OTP13130
C                                                                               OTP13140
C************************************                                           OTP13150
C OUTPUT DIAMETER CLASS VOLUME TABLES                                           OTP13160
C************************************                                           OTP13170
C                                                                               OTP13180
      DO 450 ISPEC=1,35                                                         OTP13190
        IF(CBTST(ISPEC).EQ.0.AND.PLTST(ISPEC).EQ.0)  GOTO 450                   OTP13200
        IPAGE=IPAGE+1                                                           OTP13210
        WRITE(3,100) TITLE,IPAGE                                                OTP13220
C                                                                               OTP13230
C THE FOLLOWING SECTION CONTROLS FORM CLASS PRINTING AS PREVIOUSLY              OTP13240
C DESCRIBED.  THE INPUTS OF THE LAST STRATUM ANALYSED CONTROLS WHAT             OTP13250
C IS PRINTED IN THE STRATIFIED TOTAL OUTPUT.                                    OTP13260
C                                                                               OTP13270
        AFCTIT=' ' ; AFCNUM=' '                                                 OTP13280
        IF(ISPEC.GE.33)  GOTO 370                                               OTP13290
        IF(TOPANS.EQ.'TOTAL')  GOTO 370                                         OTP13300
        IF(TOPANS.EQ.'MIXED'.AND.ISPEC.LE.11)  GOTO 370                         OTP13310
        AFCTIT='FC = '                                                          OTP13320
C ENCODE WRITES THE INTEGER VALUE OF FC INTO AFCNUM AS ASCII CHARACTERS         OTP13330
        ENCODE(2,110,AFCNUM) FC(ISPEC)                                          OTP13340
  370   WRITE(3,380) (SPETIT(ISPEC,J),J=1,3),AFCTIT,AFCNUM                      OTP13350
  380   FORMAT('0',99('*')/' *',97X,'*'/                                        OTP13360
     1' *',39X,3(A5),35X,A5,A2,X,'*'/                                           OTP13370
     2' *',97X,'*'/' ',99('*')/'0',99('-')/                                     OTP13380
     3'     DIAMETER',4X,2(':',11X,'SAWLOG',11X),':',10X,'PULPWOOD'/            OTP13390
     4'      CLASS      :',6X,'CUBIC FOOT VOLUME',5X,':',6X,'BOARD',            OTP13400
     5' FOOT VOLUME',5X,':',6X,'CUBIC FOOT VOLUME'/                             OTP13410
     6' ',99('-')/' ')                                                          OTP13420
        DO 400 DBH=CLASIZ,40,CLASIZ                                             OTP13430
          IF(CBVLST(DBH,ISPEC).EQ.0.AND.PLVLST(DBH,ISPEC).EQ.0)                 OTP13440
     1          GOTO 400                                                        OTP13450
          ICBVST=CBVLST(DBH,ISPEC)+.5                                           OTP13460
          IBDVST=BDVLST(DBH,ISPEC)+.5                                           OTP13470
          IPLVST=PLVLST(DBH,ISPEC)+.5                                           OTP13480
          WRITE(3,390) DBH,ICBVST,IBDVST,IPLVST                                 OTP13490
  390     FORMAT(' ',I8,7X,3(':',I17,11X))                                      OTP13500
  400   CONTINUE                                                                OTP13510
        ICBTST=CBTST(ISPEC)+.5 ; IBDTST=BDTST(ISPEC)+.5                         OTP13520
        IPLTST=PLTST(ISPEC)+.5                                                  OTP13530
C CALCULATE ERROR AS A PERCENT                                                  OTP13540
        IERCUB=0;IERBRD=0;IERPUL=0;TVAL=0                                       OTP13550
        IF(CBTST(ISPEC).EQ.0)  GOTO  410                                        OTP13560
        IF(EFDFCB(ISPEC).GE.1)CALL MDSTI(PROBLV,EFDFCB(ISPEC),TVAL)             OTP13570
        IERCUB=(STSECB(ISPEC)*TVAL*100*TACRES/CBTST(ISPEC))+.5                  OTP13580
  410   IF(BDTST(ISPEC).EQ.0)  GOTO 420                                         OTP13590
        TVAL=0                                                                  OTP13600
        IF(EFDFBD(ISPEC).GE.1)CALL MDSTI(PROBLV,EFDFBD(ISPEC),TVAL)             OTP13610
        IERBRD=(STSEBD(ISPEC)*TVAL*100*TACRES/BDTST(ISPEC))+.5                  OTP13620
  420   IF(PLTST(ISPEC).EQ.0)  GOTO 430                                         OTP13630
        TVAL=0                                                                  OTP13640
        IF(EFDFPL(ISPEC).GE.1)CALL MDSTI(PROBLV,EFDFPL(ISPEC),TVAL)             OTP13650
        IERPUL=(STSEPL(ISPEC)*TVAL*100*TACRES/PLTST(ISPEC))+.5                  OTP13660
  430   WRITE(3,440) ICBTST,IERCUB,IBDTST,IERBRD,IPLTST,IERPUL                  OTP13670
  440   FORMAT('0',99('-')/'0',4X,'TOTAL',6X                                    OTP13680
     1  ,3(':',I17,' +',I3,'%',5X)/'+',15X,3(19X,'_',9X)/                       OTP13690
     2  '0',99('-'))                                                           OTP13700
  450 CONTINUE                                                                  OTP13710
```

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C                                                                       OTP13720
C*********************************                                      OTP13730
C OUTPUT ALL SPECIES VOLUME TABLE                                       OTP13740
C*********************************                                      OTP13750
C                                                                       OTP13760
      IPAGE=IPAGE + 1                                                   OTP13770
      WRITE(3,100) TITLE,IPAGE                                          OTP13780
      WRITE(3,460)                                                      OTP13790
  460 FORMAT('0',99('*')/' *',97X,'*'/                                  OTP13800
     1' *',30X,'VOLUME TOTALS FOR ALL SPECIES',38X,'*'/                 OTP13810
     2' *',97X,'*'/' ',99('*')/'0',99('-')/                             OTP13820
     3' ',15X,2(':',11X,'SAWLOG',11X),':',10X,'PULPWOOD'/               OTP13830
     4'     SPECIES    :',6X,'CUBIC FOOT VOLUME',5X,':',6X,'BOARD ',    OTP13840
     5'FOOT VOLUME',5X,':',6X,'CUBIC FOOT VOLUME'/                      OTP13850
     6' ',99('-')/' ')                                                  OTP13860
      DO 480 ISPEC=1,35                                                 OTP13870
        IF(CBTST(ISPEC).EQ.0.AND.PLTST(ISPEC).EQ.0.AND.ISPEC.LT.33)     OTP13880
     1        GOTO 470                                                  OTP13890
        ICBTST=CBTST(ISPEC)+.5 ; IBDTST=BDTST(ISPEC)+.5                 OTP13900
        IPLTST=PLTST(ISPEC)+.5                                          OTP13910
        WRITE(3,310) (SPETIT(ISPEC,J),J=1,3),ICBTST,IBDTST,IPLTST       OTP13920
  470   IF(ISPEC.EQ.32.OR.ISPEC.EQ.34.OR.ISPEC.EQ.35)  WRITE(3,250)      OTP13930
  480 CONTINUE                                                          OTP13940
      RETURN                                                            OTP13950
      END                                                               OTP13960
```

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C                                                                       MDST0010
      SUBROUTINE MDSTI (Q,P,X)                                          MDST0020
C                                                                       MDST0030
C*************************************************************************MDST0040
C                                                                       MDST0050
C     THIS SUBPROGRAM IS COMPOSED OF TWO SUBROUTINES ADAPTED FROM THE   MDST0060
C     INTERNATIONAL MATHEMATICAL AND STATISTICAL LIBRARIES,INC. (IMSL)  MDST0070
C       MDSTI  -  INVERSE STUDENT'S T DISTRIBUTION                      MDST0080
C       MDNRIS -  INVERSE NORMAL PROBABILITY DISTRIBUTION FUNCTION      MDST0090
C     BOTH SUBROUTINES HAVE BEEN EDITED REMOVING CAPABILITIES NOT NEEDED MDST0100
C     IN THIS APPLICATION.  THE REMAINING CODE IS REPRODUCED HERE IN    MDST0110
C     ACCORDANCE WITH THE IMSL POLICY ON RESEARCH WORK AS STATED ON     MDST0120
C     PAGE INTRO-22 OF THE JULY, 1977 LIBRARY MANUAL.                   MDST0130
C                                                                       MDST0140
C*************************************************************************MDST0150
C                                                                       MDST0160
C                                     EXACT INTEGRAL FOR 2 D.F.         MDST0170
      IF (ABS(P-2.0) .GT. .000001)  GO TO 10                            MDST0180
      X = SQRT(2.0/(Q*(2.0-Q))-2.0)                                     MDST0190
      GO TO 50                                                          MDST0200
   10 HPI = 1.570796                                                    MDST0210
C                                     EXACT INTEGRAL FOR 1 D.F.         MDST0220
      IF (ABS(P-1.0) .GT. .000001)  GO TO 20                            MDST0230
      A = Q*HPI                                                         MDST0240
      X = COS(A)/SIN(A)                                                 MDST0250
      GO TO 50                                                          MDST0260
C                                     EXPANSION FOR N GREATER THAN 2    MDST0270
   20 A = 1.0/(P-0.5)                                                   MDST0280
      B = 48.0/(A*A)                                                    MDST0290
      C = ((20700.*A/B-98.)*A-16.)*A+96.36                              MDST0300
      D = ((94.5/(B+C)-3.0)/B+1.0)*SQRT(A*HPI)*P                        MDST0310
      XX = D*Q                                                          MDST0320
      Y = XX**(2.0/P)                                                   MDST0330
      IF (Y .GT. A+.05)  GO TO 40                                       MDST0340
      Y = ((1.0/(((P+6.0)/(P*Y)-0.089*D-0.822)*(P+2.0)*3.0)+            MDST0350
     1    0.5/(P+4.0))*Y-1.0)*(P+1.0)/(P+2.0)+1.0/Y                     MDST0360
   30 X = SQRT(P*Y)                                                     MDST0370
      GO TO 50                                                          MDST0380
C                                     ASYMPTOTIC INVERSE EXPANSION ABOUT MDST0390
C                                     NORMAL                            MDST0400
   40 X = .5 * Q                                                        MDST0410
      CALL MDNRIS(X,XX)                                                 MDST0420
      Y = XX * XX                                                       MDST0430
      IF (P .LT. 5.)  C = C+0.3*(P-4.5)*(XX+0.6)                        MDST0440
      C = (((.05*D*XX-5.0)*XX-7.0)*XX-2.0)*XX+B+C                       MDST0450
      Y = (((((0.4*Y+6.3)*Y+36.)*Y+94.5)/C-Y-3.0)/B+1.0)*XX             MDST0460
      Y = A*Y*Y                                                         MDST0470
      D = Y                                                             MDST0480
      Y = .05*Y*Y+Y                                                     MDST0490
      IF (Y .GT. .002)  Y = EXP(D) - 1.0                                MDST0500
      GO TO 30                                                          MDST0510
   50 RETURN                                                            MDST0520
      END                                                               MDST0530
```

```
      SUBROUTINE MDNRIS(P,Y)                                            MDNR0010
      DATA               SQRT2/1.4142136/                               MDNR0020
      DATA               A1,A2,A3/-.57517029,-1.8965133,-.054962605/    MDNR0030
      DATA               B0,B1,B2,B3/-.11377303,-3.2934740,-2.3749959,  MDNR0040
     1                             -1.1875145/                          MDNR0050
      DATA               C0,C1,C2,C3/-.11466659,-.13147744,-.23682010,  MDNR0060
     1                            .050739749/                           MDNR0070
      DATA               D0,D1,D2/-44.279769,21.985462,-7.5861027/      MDNR0080
      DATA               E0,E1,E2,E3/-.0566842208,.39370209,-.31665010, MDNR0090
     1                            .062089629/                           MDNR0100
      DATA               F0,F1,F2/-6.2667859,4.6662627,-2.9628832/      MDNR0110
      DATA               G0,G1,G2,G3/.00018511591,-.0020281520,         MDNR0120
     1                            -.14983844,.010786386/                MDNR0130
      DATA               H0,H1,H2/.099529751,.52117329,-.068883009/     MDNR0140
      GO TO 40                                                          MDNR0150
   10 IF (X.LT. .15)  GO TO 30                                          MDNR0160
      IF (X.LT.1.85)  GO TO 20                                          MDNR0170
      SIGMA = -1.                                                       MDNR0180
      A = 2.-X                                                          MDNR0190
      B = X-1.                                                          MDNR0200
      GO TO 50                                                          MDNR0210
   20 Z = 1.-X                                                          MDNR0220
      SIGMA = SIGN(1.,Z)                                                MDNR0230
      Z = ABS(Z)                                                        MDNR0240
      GO TO 80                                                          MDNR0250
   30 SIGMA = 1.                                                        MDNR0260
      A = X                                                             MDNR0270
      B = 1.-X                                                          MDNR0280
      GO TO 50                                                          MDNR0290
C                                  INVERSE GAUSSIAN ENTRY               MDNR0300
   40 INT = 3                                                           MDNR0310
      X = 2.*P                                                          MDNR0320
      GO TO 10                                                          MDNR0330
C                                  REDUCED ARGUMENT IS IN (.85,1.),     MDNR0340
C                                     OBTAIN THE TRANSFORMED VARIABLE   MDNR0350
   50 W = SQRT(-ALOG(A+A*B))                                            MDNR0360
      IF (W.LT.2.5)   GO TO 70                                          MDNR0370
      IF (W.LT.4.)  GO TO 60                                            MDNR0380
C                                  W GREATER THAN 4., APPROX. F BY A    MDNR0390
C                                     RATIONAL FUNCTION IN 1./W         MDNR0400
      WI = 1./W                                                         MDNR0410
      SN = ((G3*WI+G2)*WI+G1)*WI                                        MDNR0420
      SD = ((WI+H2)*WI+H1)*WI+H0                                        MDNR0430
      F = W + W*(G0+SN/SD)                                              MDNR0440
      GO TO 90                                                          MDNR0450
C                                  W BETWEEN 2.5 AND 4., APPROX. F      MDNR0460
C                                     BY A RATIONAL FUNCTION IN W       MDNR0470
   60 SN = ((E3*W+E2)*W+E1)*W                                           MDNR0480
      SD = ((W+F2)*W+F1)*W+F0                                           MDNR0490
      F = W + W*(E0+SN/SD)                                              MDNR0500
      GO TO 90                                                          MDNR0510
C                                  W BETWEEN 1.13222 AND 2.5, APPROX.   MDNR0520
C                                     F BY A RATIONAL FUNCTION IN W     MDNR0530
   70 SN = ((C3*W+C2)*W+C1)*W                                           MDNR0540
      SD = ((W+D2)*W+D1)*W+D0                                           MDNR0550
      F = W + W*(C0+SN/SD)                                              MDNR0560
      GO TO 90                                                          MDNR0570
C                                  Z BETWEEN 0. AND .85, APPROX. F      MDNR0580
C                                     BY A RATIONAL FUNCTION IN Z       MDNR0590
   80 Z2 = Z*Z                                                          MDNR0600
      F = Z+Z*(B0+A1*Z2/(B1+Z2+A2/(B2+Z2+A3/(B3+Z2))))                  MDNR0610
C                                  FORM THE SOLUTION BY MULT. F BY      MDNR0620
C                                     THE PROPER SIGN                   MDNR0630
   90 Y = SIGMA*F                                                       MDNR0640
      IF (INT.NE.3)   GO TO 100                                         MDNR0650
      Y = -Y*SQRT2                                                      MDNR0660
  100 RETURN                                                            MDNR0670
      END                                                               MDNR0680
```

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